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APHID MOVEMENT AND VIRUS SPREAD IN SEED POTATO AREAS OF ENGLAND AND WALES, 1950-53

by M. HOLLINGS

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The seed potato areas in England and Wales lie mainly in the north and west, where conditions are less favourable for aphid multiplication and movement, so the spread of the aphid-transmitted viruses is therefore less than elsewhere. Tradition and experience have largely decided which areas are suitable for seed production, and the requirements of the Ministry's Potato Certification Scheme have been based partly on these and partly on physiographic considerations. For some time it has been thought that more precise criteria were desirable for better delimitation of the areas eligible for the various grades of certificate, and a series of co-operative experiments was started in 1950 to find suitable criteria, and to assess and compare existing seed-growing areas.

A great deal of work has been done on potato aphid populations in various parts of the country, and many of the surveys included data on the virus status of the crops. In general, emphasis has been placed on the maximum populations reached in leaf infestations. More recent work has indicated that winged aphids caught on sticky traps bear a much closer relationship to virus spread (Broadbent, 1950). These surveys have been thoroughly reviewed by Broadbent (1953).

EXPERIMENTAL PROCEDURE

Ten representative sites were chosen in each of the years 1950, 1951 and 1952; eight sites being in seed areas, and two, for purposes of comparison, in ware areas. In 1953 there were six centres, in seed areas only. A standard experimental layout was used throughout and the field work was carried out by local N.A.A.S. advisory officers. Each centre was supplied with one ton of a special stock of Majestic seed potatoes each year, sufficient to plant about an acre. The stock was uniform, and was virtually free from Leaf Roll and Virus Y. The crop was divided into 50 theoretical plots (45 in 1950), each plot being 5 rows wide and 28 feet long. The rest of the crop surrounding the experimental area prevented any edge effects. In 40 plots the central tuber was removed just after planting, and a virus-infected King Edward tuber was substituted. Twenty plots had Leaf Roll "infectors", and 20 had Virus Y "infectors". The remaining 10 plots, each with a healthy central plant, provided controls.

On two occasions (three in 1950), at mid-August and again at lifting time, one tuber was taken from each of the three plants on either side of the infector in the infector row, and similar samples were taken from the control plots. These sample tubers were grown on the following year at the School of Agriculture, Sutton Bonington, and there counts were made for Leaf Roll and Virus Y (Rugose Mosaic). The health of the sample plants in the crop at the start of the experiment, and the trueness to type of the infectors, were checked at each centre, and the necessary corrections made for missing plants or extraneous infections.

Trap counts of alate potato aphids in the crop were obtained by using a yellow cylindrical sticky trap, as described by Broadbent, Doncaster, Hull and Watson (1948), placed on a post in the centre of the experimental area. The sticky cover was changed weekly. Counts of aphids on the leaves were made at weekly or fortnightly intervals during the season, using the conventional

100-leaf method (Thomas and Jacob, 1943). The numbers of the four species of potato aphid found on 3 leaves (upper, middle and lower) per plant, from 33 random plants, were recorded in detail, as adult or nymph, alate or apterous. Records of numbers of leaves per plant were made at the same time, enabling results to be expressed as aphids per plant, rather than per 100 leaves (Broadbent, 1948). In addition, records were taken of aphid predators and parasites in the crop.

SPREAD OF VIRUS AT THE CENTRES

There was considerable year-to-year variation in the incidence of virus spread. In 1950, aphids entered the crop early and caused considerable spread. In comparison, 1951 was an easy year for seed production, with very late aphid immigration and very little virus spread in seed areas. In 1952, aphids came into the crop quite early, and the spread was severe, though generally less than in 1950. In 1953, aphids did not arrive in the crop until fairly late in the season, and though sizable migrations occurred later, blight destroyed the tops early, and virus spread was slight.

TABLE 1

LOCATION OF EXPERIMENTAL CENTRES AND THEIR CLASSIFICATION ACCORDING TO VIRUS SPREAD

Centre	Altitude *feet*	Spread of Virus Diseases Upper letter : Leaf Roll. Lower letter : Virus Y			
		1950	1951	1952	1953
Baronwood, Cumberland ..	400–560	A	A	A	A
		A	A	A	A
Kirkoswald, Penrith	500–600	A	A	B	A
		A	A	A	A
Dartmoor*	750–1,000	A	A	B	—
		A	B	B	—
Talgarth, Brecon	550–750	A	A	—	A
		B	C	—	B
Malton, E. Yorks	400–500	C	C	D	—
		C	B	C	—
Lleyn†, N. Wales	100–430	C	A	C	C
		C	B	C	C
Carlisle	80–240	B	A	D	B
		A	A	A	A
Dalston, Cumberland	250–280	C	A	A	A
		A	A	A	A
Terrington, Norfolk	13	D	D	D	—
		C	D	D	—
Rothamsted, Herts	420	D	D	D	—
		C	D	D	—

A (0–5 per cent of sample tubers infected) may be considered as indicating conditions excellent for seed production ; B (6–12 per cent) reasonably good conditions ; and C (13–25 per cent) conditions unsuitable for highest grade seed production. D (over 25 per cent) indicates conditions unsuitable for seed production.

Note : The first six sites in the table are at present eligible for the highest grade of Certificate (SS) ; Carlisle and Dalston lie in an area disqualified by altitude requirements ; Terrington and Rothamsted lie in purely ware areas.

* Holne, Ashburton in 1950 ; Brentor, Tavistock in 1951 ; Yellam, Chagford in 1952.

† Bodvean in 1950, 1951 ; Aberdaron in 1952, 1953.

The experimental sites can be placed in three groups, according to their suitability for seed potato production (Table 1). In the best regions virus

spread was always slight, even in a year which was bad for the country as a whole. Such regions were Penrith and Baronwood in Cumberland, and, in most years, Dartmoor. Secondly, there were sites where spread was slight in the easier years, but too great in bad years for consistently good production of the highest grade seed. Brecon and Dalston fell into this category. Thirdly, there were those areas where virus spread was regularly too great to be satisfactory for good seed production. Malton, Lleyn and Carlisle came under this heading. At Terrington and Rothamsted, both in ware-growing areas, virus spread was very great.

At most centres virus spread was very largely confined to the few plants adjacent to an infector, and it was rare to find virus in samples from a control plot, or, say, Leaf Roll in plots with Virus Y infectors. This indicated the importance of infected plants within the crop as sources of virus rather than infection in other crops. Confirmation of this was obtained when samples taken from every plant in a number of plots at one of the centres were grown on and no scattered infection was found. In the worst areas (Terrington, Rothamsted and Malton), however, there was some spread to sample plants in the control plots, indicating virus spread over a greater distance. At Terrington, where virus spread was always very great, an additional 10 plots were laid down in 1952, each with a Leaf Roll infector. These infectors were removed as soon as symptoms were visible (June 14), and tuber samples were taken from these plots in the usual way. There was a reduction in the amount of Leaf Roll in the samples from these early-rogued plots to 18·3 per cent, compared with 60·5 per cent in unrogued Leaf Roll plots, and 1·5 per cent in control plots without infectors. This indicates the very early spread at this centre and emphasizes the importance of infection sources within the crop. Spread of virus to adjacent plants cannot be definitely ascribed to alate or apterous forms, but spread to control plots must have been by winged aphids.

APHID MIGRATIONS

Immigration started during May in the ware areas, during June in the poor seed areas, but rarely occurred before the middle of July in the better seed areas. *Myzus persicae* (Sulz.) was the most numerous and most regularly occurring species on the sticky traps, though the initial immigration often failed to show up on the traps unless the aphids were numerous, as in ware areas. The population of aphids on the leaves builds up from the nymphs deposited by these winged immigrants, and reaches its peak after 4–6 weeks, though this varies from year to year. The production of winged forms by the aphids on the leaves results in the summer dispersal migration ; in the poor seed areas these alatae were often numerous (as clearly shown by the sticky traps) and were usually associated with severe virus spread. But in the better seed areas this dispersal usually did not take place until the middle of August or later, when the lower susceptibility of the maturing crop, the separation of each " hill " into virtually independent plants, and the destruction of the tops by blight, probably combined to render this aphid movement largely ineffective in spreading virus. The summer dispersal migration at these places often blended into the autumnal emigration from the crop.

The timing of aphid movements obviously determines the time of virus spread ; thus in 1950, with early immigration and dispersal, spread of Leaf Roll had taken place by mid-July at all except the best sites. In 1951, a late season, most virus spread occurred from mid-August onwards, except at the ware sites Terrington and Rothamsted. 1952 was again a year of early aphid immigration, and spread took place before the latter part of July at all except

the best sites. In 1953, the effect of early onset of blight was seen; much spread of virus occurred before the end of July at Lleyn, but at the other sites, despite considerable movement of alatae induced by blight destroying the foliage, very little virus infection could reach the tubers before the haulms were destroyed. In general, Virus Y was spread earlier in the season than

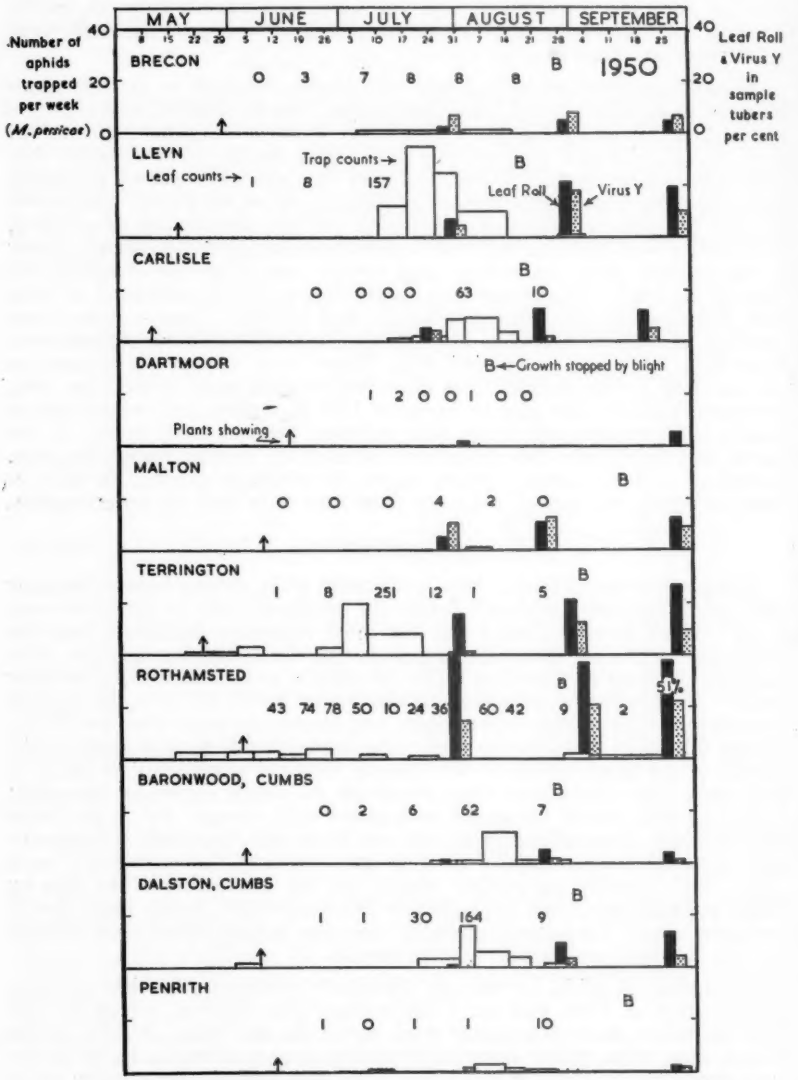

Fig. 1. Trap and leaf counts of *Myzus persicae* in relation to virus spread, 1950.

Leaf Roll, Virus Y infection being least in Cumberland and greatest on the eastern side of the country, and at Brecon, on the east of the Welsh mountains.

Leaf populations of the four potato aphid species varied greatly in relative and absolute numbers. *Myzus persicae* (Sulz.) was the most generally distributed,

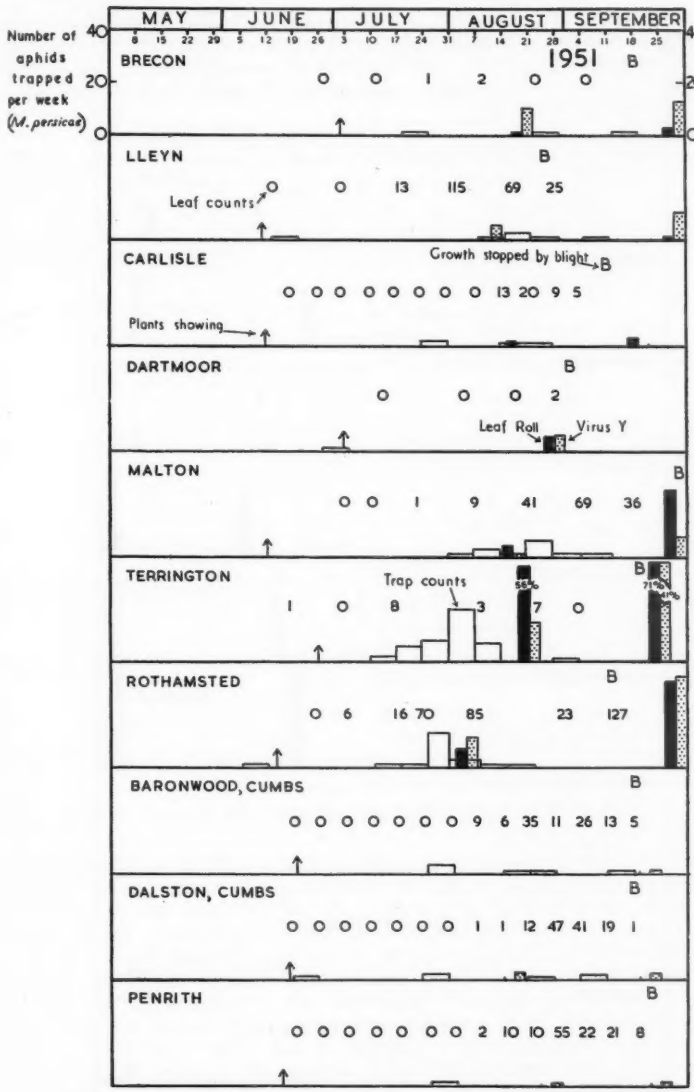

Fig. 2. Trap and leaf counts of *Myzus persicae* in relation to virus spread, 1951.

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but not always the most numerous, species; it occurred more frequently on the lower leaves, though at some centres middle and lower leaves had almost equal numbers per unit leaf area. Relatively few *M. persicae* were recorded from the upper leaves. *Macrosiphum euphorbiae* (Thos.) and *Aulacorthum solani* (Kltb.) showed similar preferences for the middle and lower leaves.

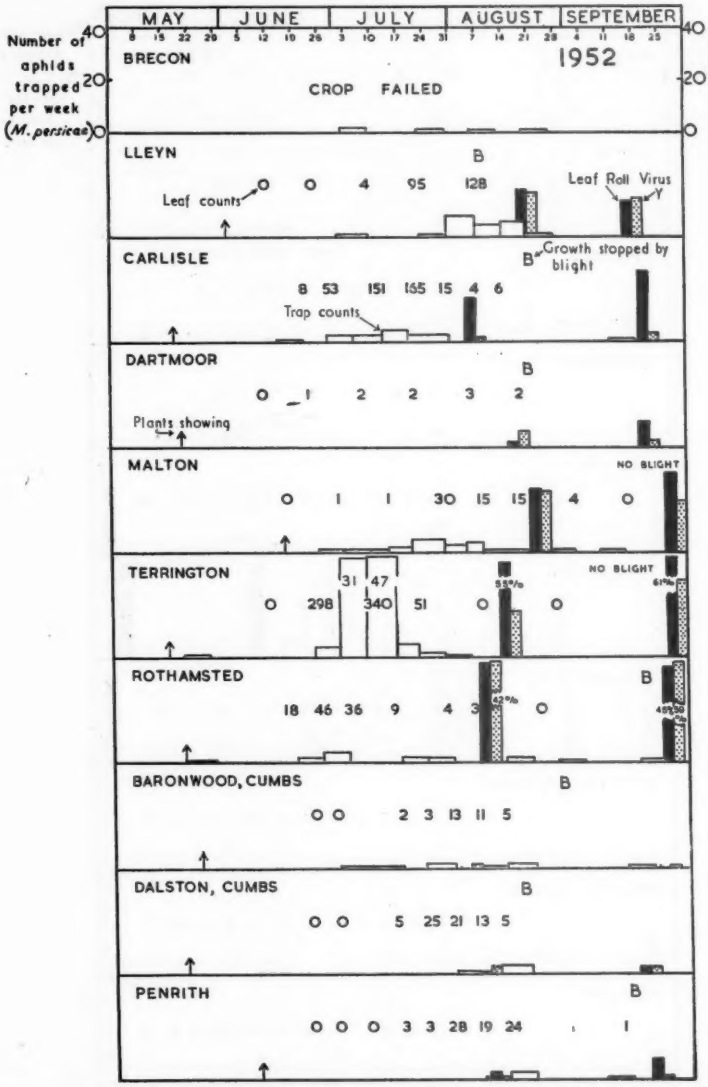

Fig. 3. Trap and leaf counts of *Myzus persicae* in relation to virus spread, 1952.

A. solani was usually the first species to colonize the plants in the north and west of the country, but its numbers frequently declined after the initial colonization, whereas populations of the other three species increased. *Aphis rhamni* Fonsc. was recorded mainly at sites on the eastern side of the country, where large populations often built up, principally on the middle and lower leaves. The restriction of large populations of *A. rhamni* to areas where its overwintering host plant (buckthorn) is common has been reported by other workers. Where early infestation with potato aphids occurred, predators and parasites usually reduced the population considerably; elsewhere, as in the better seed areas, they seemed unable to do so.

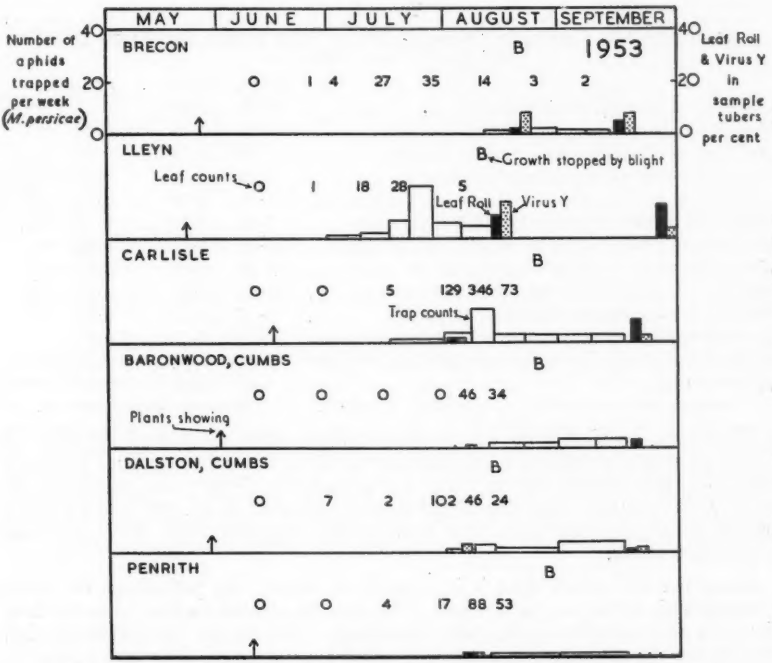

Fig. 4. Trap and leaf counts of *Myzus persicae* in relation to virus spread, 1953.

The principal aphid counts in relation to virus spread at each of the centres for the four years of the experiment are shown in Figs. 1, 2, 3 and 4. The trap counts per week are for *M. persicae* only, as the other three species of potato aphid were found to be of little importance in virus spread (see below). The leaf count figures, again for *M. persicae* only, are expressed as number of aphids per plant on each occasion. The percentage of virus-infected tubers in the samples is given for each sampling. Sometimes less virus infection was found in the second than in the first sampling, doubtless indicating a partial infection of the "hill", but in subsequent statistical analysis the maximum figure has been taken. The date of 50 per cent emergence of the crop is indicated by an arrow labelled "plants showing", while "growth stopped by blight" indicates the destruction of about 75 per cent of the foliage.

RELATIONSHIP BETWEEN VIRUS SPREAD AND APHID DATA

Covariance analyses were computed for maximum virus spread to sample tubers, in respect of Leaf Roll and Virus Y, and for the relevant potato aphid data (taken up to 14 days before the sampling). When angular transformation of the virus percentages in the sample tubers was used, each weekly trap catch of *M. persicae* converted to Log (n+1), and the season's total catch taken for each site in each year, there was a close positive correlation between the incidence of both Leaf Roll and Virus Y and the alate *M. persicae* trapped. There was no significant correlation between virus spread and trap catches of alate potato aphids other than *M. persicae* (Table 2).

TABLE 2

REGRESSION AND CORRELATION COEFFICIENTS OF VIRUS SPREAD AND APHID DATA, INCLUDING YEAR VARIATIONS

	b (+)	*S.E.*±	*r* (+)	
Leaf Roll on alate *M. persicae* trapped	6·73	0·99	0·78	***
Virus Y on alate *M. persicae* trapped	4·22	0·91	0·63	***
Leaf Roll on other alate potato aphids trapped	3·25	1·79	0·31	N.S.
Virus Y on other alate potato aphids trapped	1·08	1·44	0·13	N.S.
Leaf Roll on maximum counts *M. persicae* per plant ..	5·32	3·56	0·26	N.S.
Virus Y on maximum counts *M. persicae* per plant ..	2·80	2·83	0·17	N.S.
Leaf Roll on mean population *M. persicae* per plant ..	14·41	4·61	0·48	*
Virus Y on mean population *M. persicae* per plant ..	9·18	5·01	0·31	N.S.
Leaf Roll on angle of colonization of *M. persicae* ..	0·52	0·09	0·73	***
Virus Y on angle of colonization of *M. persicae* ..	0·35	0·08	0·62	***
Leaf Roll on angle of colonization of other potato aphids	0·31	0·13	0·40	*
Virus Y on angle of colonization of other potato aphids	0·22	0·13	0·28	N.S.
Virus Y on Leaf Roll	0·62	0·08	0·08	***

*** significant at p = 0·001. * significant at p = 0·05. N.S. not significant at p = 0·05.

There was no significant correlation between either Leaf Roll or Virus Y and maximum populations of *M. persicae* per plant, nor between either virus and maximum leaf populations of other potato aphids. There was no significant correlation between Virus Y and the mean population of *M. persicae* per plant, but there was apparently some relationship between Leaf Roll and this population index.

From the leaf count data it is possible to obtain the percentage of plants infested with aphids at each count; this can be plotted against time to show the date and rapidity of infestation build-up. The greater the aphid activity, the quicker the colonization, and this method has been devised to give a measure of total activity within the crop, apterous as well as alate. Measurement of the angle of slope of such graphs of infestation, from an arbitrary zero point taken as June 1 on the time scale to maximum infestation, give in each case an index (" Angle of Colonization "), which takes into account both earliness and speed of aphid infestation. This is distinct from the population increase due to multiplication on the plant. There was a good positive correlation between both Leaf Roll and Virus Y and this angle of colonization of *M. persicae*. To test the possibility that an equally satisfactory index might in future be obtained from fewer leaf counts taken early in the season, the angle of colonization of *M. persicae* was measured to the 50 per cent infestation level in each case. The correlation was rather less close, though still highly significant. This again stresses the importance of aphid activity early in the season. The relationship of the two viruses with angles of colonization of potato aphids other than *M. persicae* was either not significant, or on the borderline of

significance at the 5 per cent point. These analyses emphasize the importance of *M. persicae*, and suggest that other potato aphids are of little consequence in the spread of Leaf Roll and Virus Y in the field.

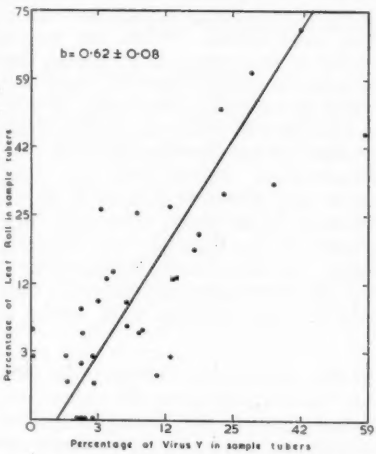

Fig. 5. Regression of Virus Y on Leaf Roll.

The correlation of Leaf Roll with the aphid data has been consistently closer than that of Virus Y. As the pattern of spread of Virus Y has been more erratic than that of Leaf Roll, and as Leaf Roll is both the more serious problem in the field and usually has a higher percentage incidence in the crop than Virus Y, the incidence of Leaf Roll appeared a better practical indicator of the suitability of an area for seed production. Also, there was a close correlation between the occurrence of Leaf Roll and Virus Y at the sites (Table 2 and Fig. 5).

Regression coefficients of Leaf Roll and Virus Y on alate *M. persicae* trapped, and on the angle of colonization of *M. persicae*, were calculated; almost identical values were obtained whether or not variations due to years were eliminated, differences between sites being so much greater than differences between years at each site. The mean value for Leaf Roll in the sample tubers in all the crops was approximately 12 per cent; this figure was found, by observation, to coincide with an approximate doubling of the overall infection in the whole crop. This one-fold increase in the number of infections should be a reasonable upper limit for the production of the highest grade of seed. The relationships between the data for *M. persicae* and Leaf Roll are reasonably linear (Fig. 6), indicating consistent behaviour of the sites, with few anomalies, and a clear distinction between sites with more than one-fold increase and those with less.

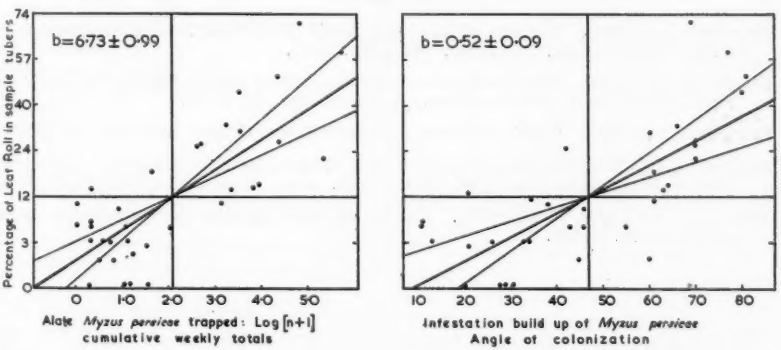

Fig. 6. Regression of Leaf Roll on alate *Myzus persicae* trapped, and on the Angle of Colonization of *M. persicae*. The 5 per cent fiducial limits are shown.

CONCLUSIONS

With so many variables, accurate prediction of the amount of virus infection at any given index of aphid movement cannot be expected, but the results of these experiments have been sufficiently consistent to suggest that sites can be classified from aphid data as to *potential* virus spread. When the various centres in these trials were arranged in order of increasing virus spread, they were found to be in very nearly the same order in each of the four years, but, of course, the range of actual values varied considerably from year to year. Thus Carlisle showed less than 5 per cent Leaf Roll in 1951—equivalent to the standard of the best seed areas—but more than 25 per cent Leaf Roll in 1952, which was in the same category as the ware areas. In the other two years, intermediate values were found. This centre may therefore be said to have a high potential virus spread which did not occur in all years. But even when aphid movement is great, the potential may not be realized ; for example, when there is early leaf destruction by blight. On the other hand, Baronwood showed less than 5 per cent Leaf Roll in each of the experimental years, even when considerable spread occurred elsewhere. The potential virus spread at this centre is thus very low.

In assessing an area as to suitability for seed production, the potential virus spread, and the frequency with which this is realized, constitute the real criteria. It is not justifiable to classify a whole area by one or two sites (though this certainly gives a good indication of local conditions) but it is quite impracticable to run sufficient detailed experiments to cover adequately all the areas under investigation. A compromise method of using the indices of aphid activity described here (see Fig. 6) to estimate the potential virus spread has been adapted for wider survey of the areas, and further investigations on this basis have now begun.

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EXPERIMENTS ON THE CONTROL OF BULB FLY IN NARCISSUS

by H. C. WOODVILLE

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Recent American work has shown that protection against the attack of *Merodon equestris* F., can be obtained by dipping bulbs in an insecticide before planting (Doucette, C. F., *Flor. Rev.*, 1953, **111,** No. 2876, 25–6). In America, aldrin, chlordane and heptachlor were used. Bulb fly causes extensive losses to narcissus varieties in Devon and Cornwall, and preliminary dipping experiments were therefore carried out as soon as this information was received from America. Aldrin and dieldrin were the only materials available, and both were used in experiments at five sites. Both materials were used at a strength of 0·2 per cent of the actual chemical. The dieldrin stock was 15, and the aldrin 20 per cent ; the latter was an early experimental stock, and it was found that the emulsion tended to break down, so that for the experiments a volume of liquid wetter equal to the volume of the stock aldrin solution was added to each mix. The bulbs were dipped for 15 and 60 minutes and planted in the autumn of 1953. They were lifted in the summer of 1954 and assessed for fly attack.

The sites used in the experiments were : PENZANCE. On Helios. No cultivations were carried out, and the foliage was allowed to die down naturally. The dieldrin dip appeared to advance growth by a few days, while the aldrin dip slightly retarded it. CAMBORNE. On Silver Chimes and Tresemble. Silver Chimes showed some forwarding. TRURO. Some cultivations were carried out on Feu de Joie. YELVERTON. On Fortune. Growth was definitely advanced in dipped bulbs. DAWLISH. On King Alfred. Rows were ridged up twice during the summer, and this may have accounted for the low incidence of attack. Further particulars of treatments and results were as shown below :

	Helios	*Silver Chimes*	*Tresemble*	*Feu de Joie*	*Fortune*	*King Alfred*
Number of bulbs	959	500	381	1,100	600	586
Warm-water treatment						
Hours at 110° F.	3	1	1	3	3	3
Date of treatment (1953)..	Aug. 24	Early Sept.	Early Sept.	Sept. 4	Aug. 21	End of Aug.
Date dipped (1953) ..	Aug. 26	Sept. 7	Sept. 7	Sept. 4	Aug. 21	Sept. 10
Date planted (1953) ..	Aug. 27	Mid-Sept.	Mid-Sept.	Sept. 4	Late Aug.	Sept. 10
Date lifted (1954) ..	Aug. 4	July 19	July 19	Aug. 4	Aug. 19	Aug. 10
Percentage of bulbs with *Merodon* larvae						
Control	10	17	35	29	21	4
Dieldrin	1	1	1	1	0	0
Aldrin	1	0	2	2	0	0

The 15-minute dip in 0·2 per cent insecticide gave complete protection in all cases, except for Feu de Joie, where there was a 1 per cent attack. The 60-minute dip showed slight infestation and the results are given in the table. No signs of phytotoxicity were seen after treatment.

In another trial (at Ellbridge Experimental Station, Cornwall) the dosage rate was doubled to 0·4 per cent of the actual chemical. In each batch 105 bulbs were treated. Of the controls, 24 per cent were damaged by *Merodon* larvae, and 55 flowers were picked. Of the bulbs treated with dieldrin for

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15 minutes, 1 per cent were damaged by larvae ; of those dipped for 60 minutes, 0·5 per cent were damaged. The flowers picked numbered 82 and 66 respectively. The aldrin-treated bulbs were completely clean after the 60-minute dip, and those treated for 15 minutes showed 0·5 per cent bulbs damaged. The numbers of flowers picked were 65 and 62 respectively.

In further experiments, dieldrin was added to a warm-water bath at 0·05 per cent and 0·1 per cent, and bulbs treated for 3 hours at 110° F. They were then planted at two sites. No fly damage was found on the treated bulbs, but 15·5 per cent of the controls were attacked. Unfortunately, there were quite severe phytotoxic symptoms shown on the bulbs which had been treated with the dieldrin. A measure of the damage was provided by the number of flowers picked. These were—from the control, 99 flowers ; dieldrin at 0·05 per cent, 73 ; and after dieldrin at 0·1 per cent, 24 flowers.

Thanks are due to Mr. Arthur Tomlin, Mr. Alex Gray, Mr. Eric Shone, Mr. G. N. Lane-Claypon and Mr. T. A. Bagley for their permission to hold trials on their holdings ; and to the Horticultural Advisory Officers of Devon and Cornwall for their help in the work.

A NEW TYPE OF EELWORM COUNTING DISH

by H. G. MORGAN

National Agricultural Advisory Service, Starcross, Exeter

The counting of eelworm larvae from hatching tests is usually carried out by means of dilution counts using modified MacMaster counting slides (Goodey, 1951). When for any reason it is desired to carry out total hatch counts, the dilution method is inapplicable, and various types of squared or ringed glass watchglasses have been used. At Starcross, rectangular Perspex dishes have also been used ; a grid of squares is ruled on the surface of a rectangle of Perspex sheet with a fine needle, and the ruled area surrounded by a frame of the same material cemented to the surface (Plate II, 1). There are, however, disadvantages with this type of counting dish. In the first place, it is not easy with an ordinary diamond to engrave lines on glass which are sufficiently fine and regular to avoid eelworm being trapped in the furrow or obscured by the marginal chips ; even with Perspex, it is difficult to avoid some irregularity if the lines are firm enough to be visible under water. There is also a risk of eelworms being moved from one square to another by the water.

In an attempt to overcome these disadvantages, a dish was developed in which raised ridges form divisions between the squares. One of the cold-setting transparent resins (Miles, 1952) was used. The liquid resin was poured into a flat mould, and a cavity was formed in the upper surface by means of a suitable core suspended in the liquid. When polymerization was complete, the block was detached from the mould, the core removed, and the upper and lower surfaces ground parallel and polished.

Careful preparation of the core—which is a replica in reverse of the cavity in the counting dish—is essential. The grid is ruled on the face of the core in the form of V-shaped grooves, which form sharp ridges in the finished dish. Because of these ridges, the bottom of the dish cannot be polished, and the face of the core must be brought to a high polish by grinding and polishing with fine abrasives. Wax and similar polishes cannot be used, since they dissolve in the liquid resin mixture and produce a cloudy surface. Care must be taken to avoid forming a " flash ", which constricts the mouth of the grooves so that the core cannot be removed without damaging the ridges. The core used for forming the dish shown in Plate II, 2 was the bottom of a meat-cube tin ; the lacquer was removed with acetone and the grooves ruled in the tinplate with a scriber. A more finished core could be produced from brass or some similar metal ; an attempt to use a lead core was not successful, since detached grains of abrasive became embedded in the surface, and, even when a satisfactory surface was obtained by burnishing, the dishes had a rather poor finish, perhaps due to some inhibition of polymerization.

The form of the cavity is a matter of individual preference : rounded edges and corners are an advantage, as they facilitate cleaning with a jet of water, and avoid the danger of eelworms lodging in the crevices. It is also an advantage if the sides of the dish are not vertical, but incline outwards. This minimizes the distortion of the field of view caused by the meniscus. The rulings can be varied to suit the needs of the work. If regular squares are used, their size should be related to the numbers of eelworms expected and to the field of vision of the microscope in use. Counting becomes difficult if the number of eelworms exceeds about 10 per square, and the diagonal of the square cannot, of course, exceed the diameter of the field ; it should preferably be less than this, and the size in use at Starcross is such that the diagonal is about two-thirds of the field diameter. This reduces eyestrain in searching the periphery of the field. Eyestrain may also be eased by the use of reflected light or dark-ground illumination in place of the usual transmitted light.

This type of dish minimizes errors in counting, and it is possible to produce a number of identical dishes with any given ruling with great ease once the core is made. It has, however, the disadvantage that the material is soft and may be liable to scratch, warp or crack.

Thanks are due to Mr. H. C. Woodville for the photographs.

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THE EFFECTS OF SOME LEGUMINOUS CROPS ON THE SOIL POPULATION LEVEL OF PEA ROOT EELWORM

by R. D. WINSLOW

School of Agriculture, Cambridge

Using the " microplot " technique of Jones (1955), an experiment was conducted to determine the effects of certain legumes on the soil infestation level of Pea Root eelworm, *Heterodera göttingiana* Liebscher. Pre-crop sampling over a block of 49 microplots filled with infested, loamy sand indicated that the infestation was reasonably uniform between plots. Fifteen crops were grown in three-fold replication, the remaining four plots serving as fallow controls. All crops were sown on April 2, 1954, pea fertilizer (Fison's No. 10) being added to all plots as a top dressing at the rate of 3 cwt. per acre. Both pea varieties were crop failures, flowering prematurely when only a few inches high and dying before pod formation. Lentil and the three bean varieties gave only moderate yields, while the remaining crops were satisfactory, the clovers being especially good.

Post-crop sampling was carried out in November, after thorough digging. The results (Fig. 1) show that for the season, soil type and fertility, etc., the initial eelworm population of 127 eggs per gramme of soil was about the " ceiling " for peas and vetch—the " ceiling " being the maximum eelworm population which the crop will support under the prevailing conditions. Many small cysts were produced on peas and vetch but the contents of these cysts

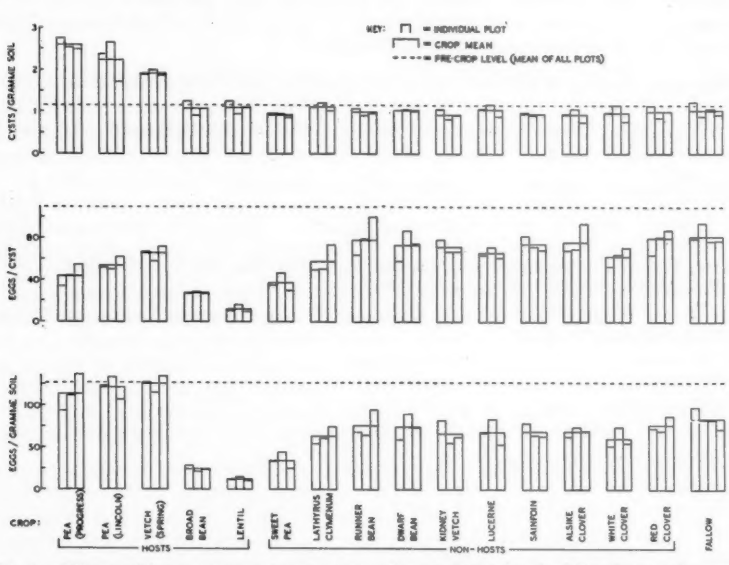

Fig. 1. Effects of leguminous crops on the soil population level of Pea Root eelworm. (Based on results from 100 gramme sample of air-dry soil per plot).

barely compensated for those lost from the older cysts. It is assumed that this loss was largely due to stimulation of larval emergence by root diffusate action in the soil, and that the small size of the cysts was due to inter-competition and, in the case of the peas, to the early death of the host. Evidence has been found of such stimulation when peas were grown in infested soil, although no hatch occurred from cysts of Pea eelworm incubated in pea root leachings in the laboratory (Franklin, 1940; Goffart, 1941; Winslow, 1955). Broad bean and lentil are hosts which evidently have a lower " ceiling "; from the post-crop cyst figures it seems that very few, if any, new cysts were formed in these plots, whereas the contents of the existing cysts were greatly reduced, probably due to hatching stimulated by diffusate action. The non-host sweet pea (*Lathyrus odoratus*) caused a considerable reduction in the eelworm population level, presumably by diffusate action, this plant being closely related to host plants (many *Lathyrus* spp.).

In the case of fallow and the remaining non-hosts, a slight fall in cyst numbers was accompanied by a substantial fall in mean cyst content, leading to an overall reduction of 34 per cent in the number of eggs per gramme of soil for fallow, with a slightly greater reduction in all other cases.

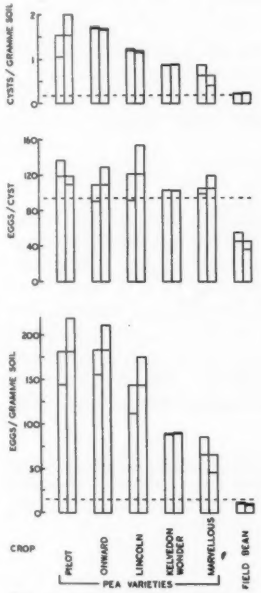

Fig. 2. Effects of pea and bean crops on the soil population level of Pea Root eelworm. (Based on results from 120 gramme sample of air-dry soil per plot). (Key as for Fig. 1).

In another experiment in 1954, good crops resulted when field beans and five pea varieties were grown in duplicate plots on sandy clay-loam lightly infested with Pea Root eelworm. The results of post-crop sampling (Fig. 2) show that the field bean, like broad bean in the previous experiment, is a host of low efficiency. Two pea varieties produced fewer cysts than did the other three. This difference, which is reflected in the final numbers of eggs per gramme of soil, may be merely a seasonal effect, and results over a number of years are required for accurate assessment of any real varietal difference of this nature.

A few results for 1953 are available, and these are given in the table, for comparison with the 1954 results. By growing peas in 1953, final eelworm population of 1,200 and 500 eggs per gramme of soil were obtained, without noticeable effect on the pea crop. In contrasting these figures with the " ceiling " of about 120 eggs per gramme in the 1954 microplot experiment, due allowance must be made for difference in depth of infested soil. When Onward peas were grown in plots where only the top 6–8-inch layer of soil was infested, overlying uninfested subsoil, the factor of increase in eelworm population level was remarkably constant, being $\times 12$, $\times 14$ and $\times 12$ in three different instances covering marked differences in season, soil type and initial infestation level. In the 1954 microplot experiment, the high initial infestation level was a feature of the top 12-inch layer of soil and overlay more lightly infested subsoil. In these circumstances the roots of the host plant could not escape

attack by extending into uninfested subsoil. This may be of practical significance in crop rotation; in a heavily infested field where peas are liable to fail, field beans may succeed by deeper rooting, and may even lead to a substantial decrease in infestation level, as was the case in one of the above experiments (Fig. 2). In any case, broad and field beans appear to be less susceptible and less efficient hosts than are peas.

PEA ROOT EELWORM INFESTATION LEVELS (EGGS PER GRAMME OF SOIL) IN 1953 AND 1954 EXPERIMENTS

	1953		1954	
	Microplot	Microplot	Microplot	Field Plot
	A	*B*	*C*	*D*
Initial level	100	35	127	15
After fallow	70	—	84	—
After hosts :				
Pea (Onward)	1,200	500	—	183
Pea (Lincoln)	—	—	121	144
Vetch	—	—	126	—
Broad Bean	—	—	25	—
Field Bean	—	—	—	11
Lentil	—	—	13	—
After non-hosts :				
Oat	60	—	—	—
Legumes (general)	—	—	60–78	—
Sweet Pea	—	—	34	—

A. Infested soil 6–8 inches deep. Subsoil uninfested.
B. 2 : 1 mixture of sterilized loam and infested soil 6–8 inches deep. Subsoil uninfested.
C. Infested soil 12 inches deep, overlying lightly infested subsoil.
D. Uninfested, sandy clay loam inoculated with a little infested soil.
The infested soil used was a loamy sand from a field in E. Suffolk.

The vetch crop maintained the eelworm population level and, at first sight, appears to be at least as efficient a host crop as pea. Fewer cysts were produced on vetch but they were able to develop more fully than those on pea, which were very small. The season was unfavourable for pea-growing; in a better year a pea crop would probably tolerate this higher cyst density and increase the infestation more than a vetch crop. However, the results suggest that vetch is capable of supporting an undesirably high eelworm population and should not be grown in soil infested with Pea Root eelworm. The reduction in infestation by growing lentil and sweet pea is of academic interest but of no practical importance in crop rotation.

I wish to thank Mr. T. A. Askew, of Aldringham, E. Suffolk, for supplying eelworm-infested soil; and my colleagues in the School of Agriculture for assisting in the work, especially Mr. F. G. W. Jones for his interest and advice and for placing the microplots at my disposal, and Messrs. R. Day and P. Halfpenny for field and laboratory assistance.

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MALEIC HYDRAZIDE AS A SHOOT DEPRESSANT FOR CLAMPED MANGOLDS AND FODDER BEETS

by C. E. CORNFORD

Rothamsted Experimental Station

(*Dunholme Field Station, near Lincoln*)

The shoots produced on clamped mangolds and fodder beets are often overwintering sites for the aphid *Myzus persicae* Sulz. They consist of rosettes of etiolated leaves, the largest of which may reach nine inches long. The aphids usually occur on the lower sides of the leaves ; most colonies in March consist of one or two aphids, but in April and May there may be as many as twenty aphids per leaf, or about 100,000 aphids per ton of mangolds. Mangolds are grown in all English counties and observations over much of England during the past seven years showed that, on average, 15 per cent of the clamps were infested with *M. persicae* in the spring. This source of *M. persicae* near the farm probably plays an important part in the aphid infestation of sugar beet and potato crops, and, consequently, in the spreading of certain virus diseases.

The spraying of growing crops with maleic hydrazide is a possible solution to the problem of eliminating aphids from the clamps. Schoene and Hoffman (1949) first investigated the growth-regulating properties of this material, and Wittwer and Hansen (1951), and Gautheret *et al.* (1954), have studied its effect on sugar beet. Preliminary experiments at Dunholme in 1952 indicated that mangolds and fodder beets were sufficiently affected by maleic hydrazide to warrant further tests to find the relation between time of spraying and the extent to which sprouting was suppressed.

Orange Globe mangolds and Hunsballe fodder beets were sprayed on September 2, October 16 and November 4, 1953 with 1·0, 0·5, 0·25, and 0·12 per cent solutions of maleic hydrazide in a triethanolamine formulation, with the addition of a wetting agent. The spraying was done with a knapsack sprayer at the rate of about 100 gallons per acre. The plots were four rows wide and fifteen feet long. The roots were harvested on November 4, 1953, and clamped in a field. The clamps were opened on April 7, 1954, when the mean length of the sprouts on ten random plants from each plot was determined (Table 1).

TABLE 1

MEAN SHOOT LENGTH OF MANGOLDS AND FODDER BEETS STORED IN CLAMPS AND MEASURED ON APRIL 7, 1954 (INCHES)

Maleic Hydrazide in Spray *per cent*	Orange Globe Mangold Sprayed on			Hunsballe Fodder Beet Sprayed on		
	Sept. 2	Oct. 16	Nov. 4	Sept. 2	Oct. 16	Nov. 4
1·0	0·3	0·0	0·3	0·0	0·4	0·6
0·5	2·1	0·1	0·3	2·4	0·6	0·0
0·25	4·2	0·3	0·3	3·2	0·8	0·1
0·12	3·4	0·1	0·8	2·9	3·3	2·3
0·0	4·2	4·3	4·1	3·5	4·0	3·7

The October sprays were most effective in reducing the sprouting of mangolds (Plate 1) ; of those sprayed with a 0·25 per cent solution, seven out of ten had no sprouts, two had sprouts a quarter of an inch long, and one had a single weak sprout three inches long. It seems that the September sprays had lost

some of their sprout-inhibiting effect by the time the plants were clamped in December, and the November sprays were too late to prevent some sprouts from being produced in December. All the roots from the unsprayed plants sprouted freely.

Sprouting in fodder beets was most efficiently controlled by the November sprays ; the effectiveness of the sprays applied on November 4 may be judged from the fact that of the ten fodder beets treated with 0·25 per cent solution, eight had no sprouts and two had one sprout each, one a quarter of an inch and the other one-and-a-half inches long. All the roots from the unsprayed plants sprouted freely.

In mid-December some roots from each plot were stored in a cellar at about 40° F., and the rate of growth of the sprouts was studied (Table 2). The unsprayed plants sprouted at once—they had sprouts seven inches long on January 5 and nine inches long on March 29. In contrast, the mangolds sprayed with the 0·25 per cent solution on October 16 produced shoots two inches long by January 5, but within two weeks these shoots died. More shoots appeared and were three inches long on February 15, but these shoots also died, and on March 29 there were no shoots. The fodder beets sprayed with 0·25 per cent solution on November 4 produced shoots one inch long and retained them at this length to the end of March, when the experiment ended.

TABLE 2

MEAN SHOOT LENGTH OF MANGOLDS AND FODDER BEETS STORED IN A CELLAR AND MEASURED ON MARCH 29, 1954 (INCHES)

Maleic Hydrazide in Spray *per cent*	Orange Globe Mangold Sprayed on			Hunsballe Fodder Beet Sprayed on		
	Sept. 2	Oct. 16	Nov. 4	Sept. 2	Oct. 16	Nov. 4
1·0	0·2	0·0	3·0	1·0	1·0	2·0
0·5	4·5	0·0	3·5	2·5	2·0	5·0
0·25	6·0	0·5	4·0	5·0	2·5	1·0
0·12	8·0	0·2	2·0	3·0	6·5	4·5
0·0	9·0	7·5	9·5	7·0	7·0	10·0

To sum up, a solution of 0·25 per cent of maleic hydrazide sprayed on growing mangold plants in mid-October, and on fodder beet in early November, strongly inhibited the growth of sprouts on the roots stored in clamps or in a warm cellar, and probably reduced sprouting to well below the amount necessary to support an aphid population over the winter. The time of spraying had an important effect on the extent to which sprouting was suppressed.

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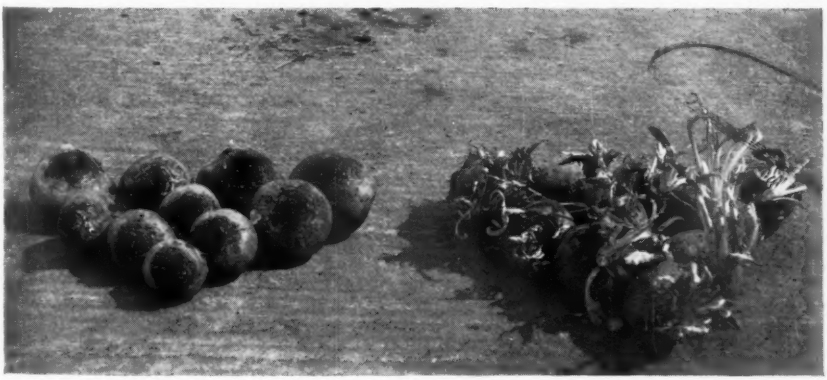
1. Orange Globe mangolds on April 6, 1954. *Right:* sprayed with 0·25 per cent maleic hydrazide on October 16, 1953. *Left:* unsprayed.

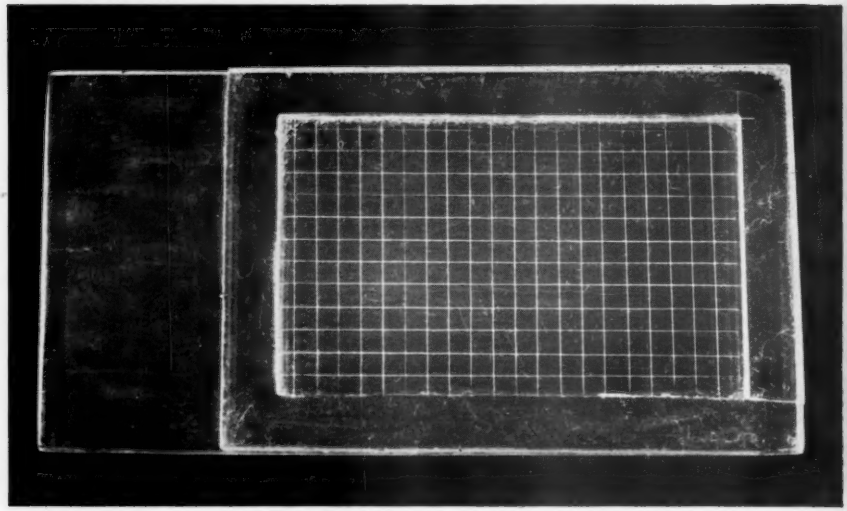


Photos : Rothamsted Experimental Station

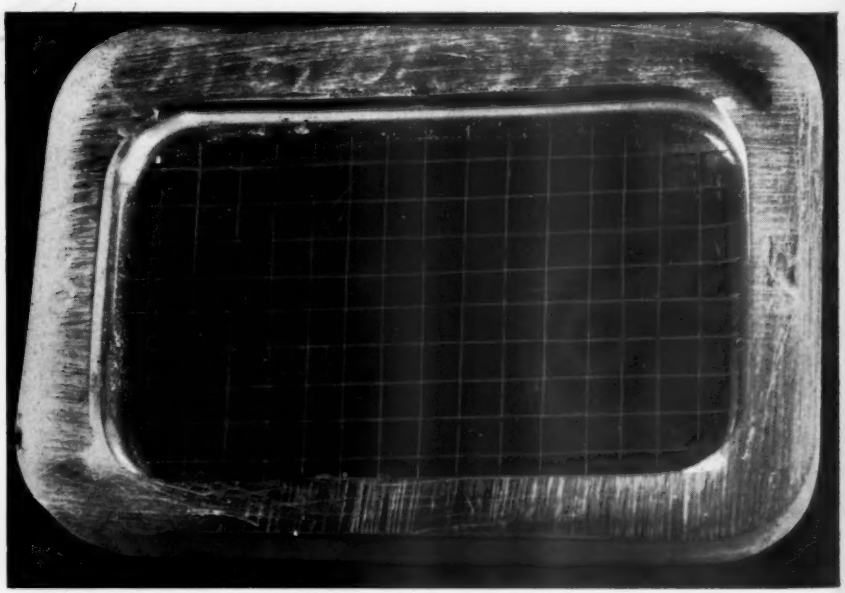
2. Orange Globe mangolds on April 22, 1954. *Left:* sprayed with 0·25 per cent maleic hydrazide on October 16, 1953. *Right:* unsprayed.

PLATE I

A NEW TYPE OF EELWORM COUNTING DISH (*see p. 84*)



1. Rectangular Perspex dish with ruled grid.

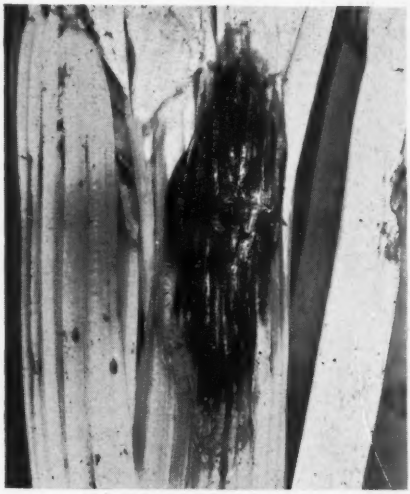


2. Cast plastic dish with embossed grid.

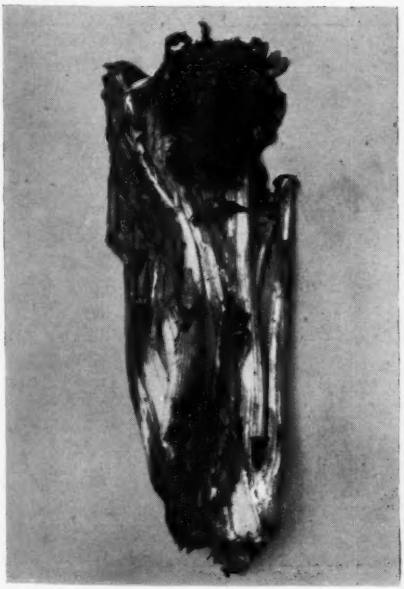
PLATE II

STORAGE ROTS OF CELERY (see p. 106)

1. Celery plant attacked by *Centrospora acerina*. The crown has fallen completely away.



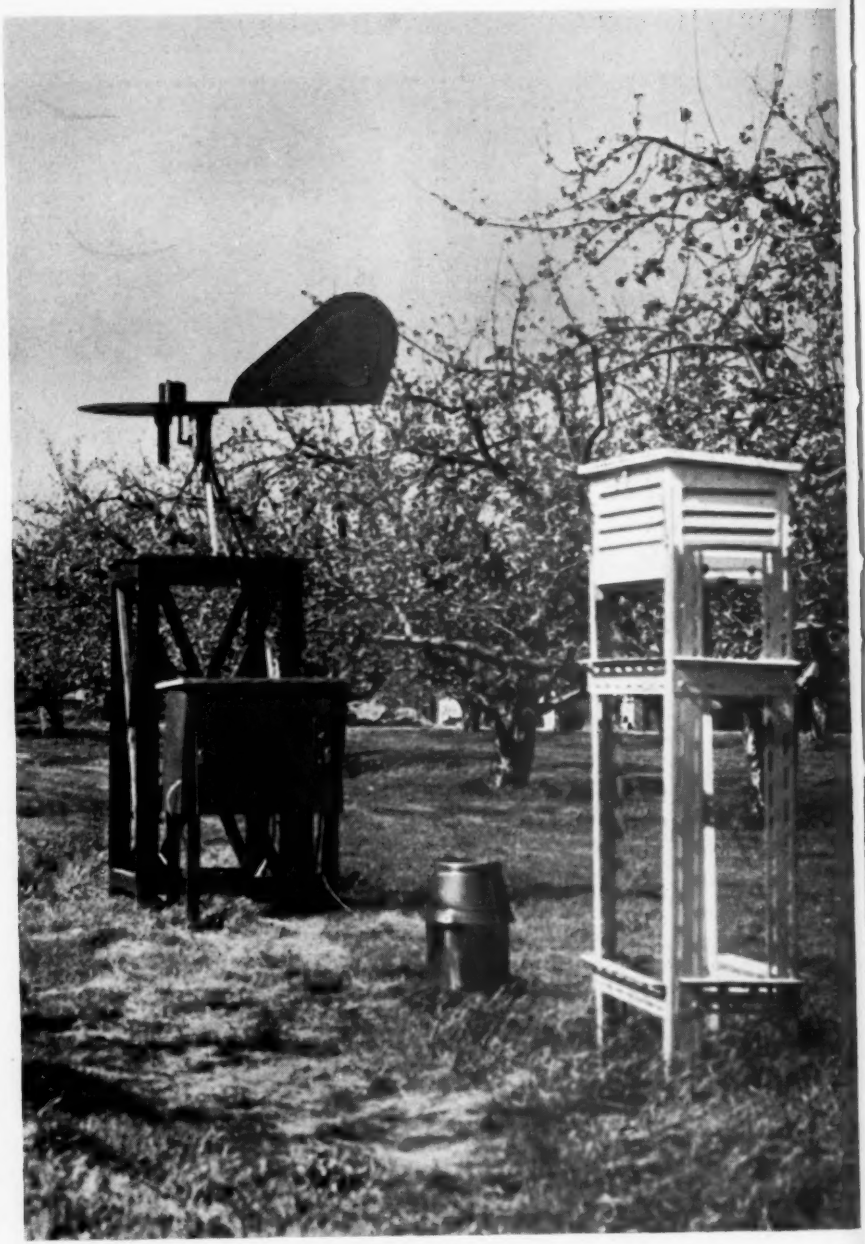
2. Rot of the upper petiole following wound infection by *C. acerina*.



3. Celery attacked by *Sclerotinia sclerotiorum*.

4. *Septoria apii-graveolentis:* blight developed during storage.

PLATE III



1. Spore trap, rain gauge, and thermograph screen in an orchard of Bramley's Seedlings at Wisbech.

PLATE IV

THE ORIGIN OF APPLE SCAB EPIDEMICS IN THE WISBECH AREA IN 1953 AND 1954

by J. M. HIRST

Rothamsted Experimental Station, Harpenden, Herts

AND I. F. STOREY, W. C. WARD AND H. J. WILCOX

National Agricultural Advisory Service, Cambridge

For many years it has been recognized that Apple Scab, *Venturia inaequalis* (Cooke) Wint., is unusually difficult to control in the Fenland area around Wisbech. There are many possible explanations. The soils of the area are fertile reclaimed silts with a high water-table which produce luxuriant growth. In addition, many of the orchards lie below high water level and air movement is impeded, so that periods of high humidity may persist longer than elsewhere and favour infection by the fungus. The possibility that a specialized race of *V. inaequalis* has developed locally is supported by the fact that the main variety, Bramley's Seedling, is now susceptible, although at one time it was recorded as resistant (Cheal, 1935). The results of spraying trials in the district by Petherbridge *et al.* (1929) and Cheal (1935, 1938 and 1947) all stressed the importance of pre-blossom protection, and there is a local tradition that applying fungicidal sprays as early as bud-burst improves the control of scab.

Keitt and Jones (1926) showed that ascospores were important in originating epidemics in Wisconsin, but not all workers have agreed they are equally important in this country. Salmon and Ware (1924) and Moore (1939) observed dead apple leaves microscopically and determined the dates when ascospores were liberated from perithecia ; they concluded that ascospores played an important part in initiating epidemics. On the other hand, although variously orientated sticky microscope slides erected as spore traps caught some conidia among the branches of apple trees, ascospores were rarely caught unless the slides were very close to perithecia in dead leaves lying on the ground. Dillon Weston and Petherbridge (1933) found mature perithecia in February 1932 but did not catch ascospores until April 12, when the trees already had scab lesions, which they presumed to have originated from conidia. They considered that ascospores had not been important in causing the earliest infections in 1932. Marsh (1931) was more conservative in the conclusions which he drew from similar evidence.

Recent wind-tunnel tests of spore deposition (Gregory and Stedman, 1953) suggested that freely exposed sticky microscope slides would not efficiently catch conidia of *V. inaequalis* and that they would be even less successful with the smaller ascospores. Keitt and Jones detected high concentrations of ascospores by using a type of power-operated suction trap. It seemed possible, therefore, that the importance of ascospores had been underestimated where only inefficient traps had been used. To test this possibility, an automatic volumetric spore trap of the type described by Hirst (1952), was operated in the spring of 1953, and again in 1954, to find which were the commoner, conidia or ascospores, and which the more likely to have caused the first infections.

SPORE TRAPPING METHODS

The grass orchard at Wisbech St. Mary, in which the trap was placed, contained Bramley's Seedling trees about 40 years old and 15–20 feet high. The trap was installed in March each year, when dead leaves lying under the

trees were examined and some found to contain perithecia. These perithecia appeared to be the most common method by which the fungus overwinters in the Bramley's Seedling orchards of this district, for, despite careful examination, no conidial pustules on wood have been found there on Bramley's Seedling in recent years. A few overwintering bud-scale infections similar to those described by McKay (1938) were found in the spring of 1952 (Dillon Weston *et al.*, 1952), but none has been found since, although many buds were examined in both 1953 and 1954.

In addition to the spore trap, a recording rain gauge was installed in the orchard each year, together with a bimetallic thermograph in a louvred screen four feet above ground level (Plate IV). In 1954 hair hygrograph records were also made. The trap was placed in a row of widely spaced pollinator trees of mixed varieties, with its orifice two metres above ground level and considerably above the lowest branches. The springs of 1953 and 1954 had unusually long dry spells. In 1953 a cool drought, lasting nearly five weeks, ended on March 26. In 1954 the dry spell lasted from April 7 to the end of the month. In both years the week at the end of March and beginning of April had about three times its average rainfall.

Slides were prepared as described by Hirst (1953); the slide in the trap was replaced by a clean one at 09.00 G.M.T. daily from March 17 to May 13, 1953 and from March 9 to September 15, 1954. After removal from the trap, the slides were mounted and scanned to estimate the number of *V. inaequalis* spores per cubic metre of air at one- or two-hour intervals. Hourly records of wind speed were not available, so no correction could be applied for variations in the efficiency of the trap. Such " uncorrected " estimates (see Hirst, 1953) assume that the trap is 100 per cent efficient, which it never is, and are therefore all underestimates of the actual concentrations. Fortunately, both the conidia and ascospores of *V. inaequalis* are characteristic, being distinguishable even from those of *V. pirina*. Only those results from the start of trapping in March until the disease was well established in May are considered here.

THE ROLE OF CONIDIA

No conidia were caught on the slides exposed between March and May in either year. A few conidia were caught at Wisbech later in 1954, and traps operated elsewhere, among more severely scabbed trees, have recorded over 1,300 per cubic metre of air.

In each of three orchards, at least 100 twigs with healthy or infected foliage were marked between fruit picking and leaf fall in 1952, to test whether the distribution of lesions next spring was influenced by the state of the foliage on the same twigs the preceding autumn. The twigs were examined on May 13, 1953, when the disease was present in all orchards. The table below shows that twigs with infected foliage in autumn were not infected more than those which had been healthy.

Condition of Foliage, 1952	Percentage of Spurs with Infected Foliage, May 13, 1953		
	Orchard A	Orchard B	Orchard C
Scabbed	39	0	0
Clean	39	0	0

Such a distribution suggests infection from uniformly distributed ascospores, rather than conidia derived very locally from undetected infections of the wood or bud-scales.

THE PROCESS OF ASCOSPORE LIBERATION

The changes in ascospore concentration every two hours and the rainfall in each two-hour interval are shown in Fig. 1 for the periods in each year when ascospores were most frequent. Keitt and Jones (1926) found that the liberation of ascospores is correlated with rain, but our measurement of spores in the air at regular intervals allowed the relation to be studied with greater precision. Both in 1953 and 1954 there was evidence that the number of ascospores caught was sometimes influenced by the time of day at which rain fell. Few ascospores of *V. inaequalis* were caught during the first hour after the onset of rain during the day; in the second hour the number increased, and it usually reached a peak in the third hour; thereafter, the number declined, until after eight hours few were caught. When rain fell at night fewer spores were caught than after an equal rainfall during the day, or their liberation was delayed until the following morning (Fig. 1). Differences in temperature, light intensity or atmospheric turbulence may be responsible, and are now being investigated in wind-tunnel experiments. It was exceptional to get two heavy catches within 24 hours, suggesting that all mature asci liberate their spores soon after it rains, and that an interval is then necessary before other perithecia mature and liberate their spores. There was no evidence that dew wetted the perithecia sufficiently to eject spores, but a spray applied to the orchard on April 27, 1954, was followed by a very small catch of ascospores.

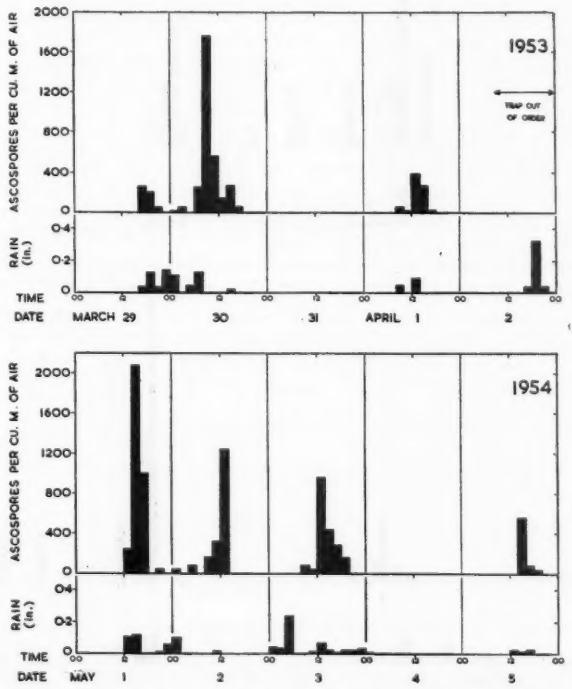


Fig. 1. Relation of rainfall and concentration of *Venturia inaequalis* ascospores every two hours during selected periods in 1953 and 1954.

ASCOSPORE LIBERATION AND DISEASE OUTBREAK IN 1953 AND 1954

The date when scab lesions were found on foliage is related, in Fig. 2, to the stages of bud development, daily rainfall, and to the daily mean ascospore concentration (average of two-hour estimates, 09.00–09.00 G.M.T.). The early stages of bud development were about two weeks later in 1954 than in 1953 and the heaviest ascospore liberation was over a month later, following green cluster rather than bud-burst. The first spores trapped in 1954 were noticed on March 9 but lay outside the areas of the slide on which spores were counted. This liberation, and others around bud-burst, did not lead to visible infection, whereas in 1953 infection must have occurred soon after bud-burst. The 1954 result may be attributed to smaller concentrations of spores, smaller areas of leaf exposed or, perhaps, to less favourable weather for infection. Moore (1939), suggested that, in Kent, ascospore liberation reached its peak shortly after the middle of April. The results from Wisbech do not disagree with this, but suggest that heavy releases occur over a much longer period than previously suggested in this country—from at least mid-March until the end of May or

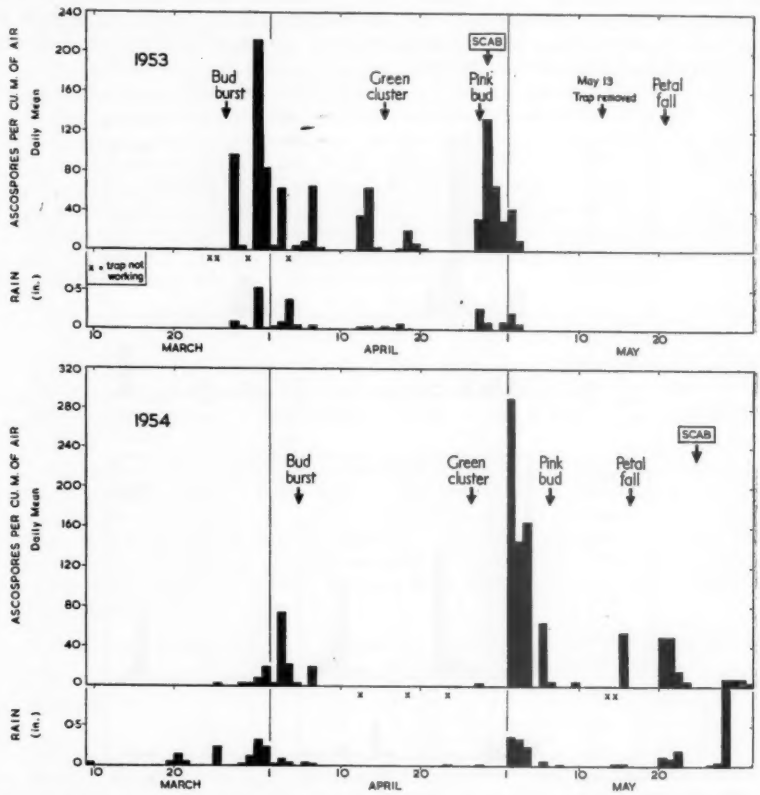


Fig. 2. Daily mean concentration of *Venturia inaequalis* ascospores related to rainfall, the development of apple buds and the outbreak of scab at Wisbech in 1953 and 1954.

early June. In most years this period extends from well before the buds are open until well after petal-fall, and well after scab appears on the foliage. The first lesions were found on April 28, 1953 and May 24, 1954, about 3–4 weeks after the first large quantity of spores was liberated following bud-burst ; Keitt and Jones described a similar interval. This, together with the lack of conidia in trap catches, on twigs or on bud-scales, makes it highly probable that ascospores provided the bulk of inoculum for the initial infection in both years. The earliest infections were on the lower sides of the leaves, exactly as figured by Salmon and Ware (1925). Infection in this position would be improbable with water-borne conidia but could easily result from airborne spores impacted on the out-facing under-surfaces of leaves just emerging from the bud.

As already described, both years had unusually long rainless spells in early spring. It seems that asci continued to mature during the dry weather and then the first considerable rain produced the heaviest concentrations of ascospores recorded. This stresses the danger of assuming that scab will be automatically checked in dry weather and that spraying is unnecessary. With protective sprays, the longer the dry spell the more essential it is to have good spray deposits on the foliage before the rain starts. The organo-mercury compounds, which can eliminate infections that have been established for a few days (Sproston, 1949), need not be applied during dry spells and can be most effectively timed if the dates of ascospore liberation are known. The number of infections established depends on the frequency and intensity of spore deposition, as well as on the suitability of leaf surface conditions for germination and penetration. Sproston has suggested how temperature and period for which leaf surfaces remain wet after spore deposition influence the number of infections established. Thus the success of a spray programme may depend on the timing of sprays in relation to a few periods of heavy spore deposition and infection.

The use of improved methods of spore trapping revealed high concentrations of ascospores early in the season. At Wisbech in 1953 and 1954 all the evidence suggested that these caused the early outbreaks of Apple Scab. Many infections can occur at bud-burst in some years, and to prevent these, sprays must either be applied earlier than at present recommended or be capable of eliminating established infections.

We are grateful to Mr. A. Hudson of Wisbech St. Mary for allowing this work to be carried out in his orchard, and also wish to thank him and Mr. P. Turner for help on many occasions.

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TRIALS ON SOIL TRANSMISSION OF TOBACCO NECROSIS VIRUSES IN TULIPS

by J. C. MATHER

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In the 1949–50 season, a bulb grower at Spalding had an almost complete failure of Zimmerman tulips forced under glass. The plants showed all the symptoms of the lethal disease caused by tobacco necrosis viruses (Kassanis, 1949). Specimens were sent to Dr. Kassanis at Rothamsted, who confirmed the presence of the viruses by inoculation tests. The stock of bulbs for forcing had been grown in a field on the grower's own holding in 1948–49, and the parent plants had appeared normal and healthy in that year. It was thought that the failure on forcing might have been due to infection from the old boxing soil in which the bulbs were planted, and the likelihood of this was indicated by the fact that bulbs of the same stock of Zimmerman forced on another nursery had shown no sign of the disease. In the years 1950–53, with the help of Dr. Kassanis and the keen co-operation of the grower, a series of transmission trials were conducted on this nursery.

In the first year of these trials, infected Zimmerman bulbs from the boxes that had failed on forcing in 1949–50, and also healthy Zimmerman from another source (found free from tobacco necrosis viruses on inoculation tests), were each boxed, in duplicate; (*a*) in "infected" soil (that is soil from the boxes in which the diseased plants had grown in the previous year); (*b*) in this same soil, steam sterilized; and (*c*) in clean soil in which tulips had never been grown before. After boxing, the bulbs were kept under straw outdoors in the normal way and they were forced in February at 60–65° F.

In all the boxes planted with *healthy* bulbs all the plants were healthy ; there were no diseased shoots. In all the boxes planted with *infected* bulbs, all the shoots which came up were diseased (with typical tobacco necrosis symptoms), and many failed to throw up any shoot at all. The counts for each box (of 55 bulbs) were as follows :

	"Infected" Soil		"Infected" Soil Steam Sterilized		Clean Soil	
	I	II	I	II	I	II
Diseased shoots	20	24	13	21	27	25
Total failures	35	31	42	34	28	30

In the second year of the trials, the variety Korneforos was substituted for Zimmerman, as it has been found to be even more susceptible to tobacco necrosis viruses. The health of the Korneforos stock was checked by inoculation tests. Diseased bulbs were not included in the trials this year, since the object was to test for possible infection of healthy stock from "infected" soil when the boxing was done normally at 48° F. or in warm soil (57° F.) and forcing was at high and at low temperatures (with maxima 70° F. and 60° F.). There were two boxes (each planted with 45 bulbs) for each treatment, using both clean soil and "infected" soil from the same heap as in the previous year. The forcing was done in mid-January. The counts of diseased shoots per box were as follows :

Boxing Temperature	Forcing Temperature	Diseased Shoots per Box of 45 Bulbs "Infected" Soil		Clean Soil	
		I	II	I	II
Normal ..	70° F.	1	5	0	0
	60° F.	0	7	0	0
Warm ..	70° F.	0	0	0	0
	60° F.	1	0	0	0

Although there was no infection of the healthy Zimmerman from the infected soil in 1950–51, there was some infection of the more susceptible Korneforos from the same soil in 1951–52.

In 1952–53 an attempt was made to test whether the growth of potatoes in boxing soil would affect its infectivity. All the boxes of "infected" soil used in the 1951–52 trial were retained and, during the summer of 1952, potatoes were grown in one of each pair, the other being left fallow. All the boxes of clean soil were also retained and treated similarly. Healthy Korneforos bulbs were planted in all the boxes in the autumn at normal outdoor boxing temperatures, and forcing was done in mid-January at 65–70° F. No symptoms of the virus disease were found among the plants in any of the boxes.

Over the three years of these trials there was little transference of the virus from soil to bulbs, and this may be accounted for by the finding of Kassanis (1954) that the plants may pick up the viruses not during the year in which they show the disease, but during the previous year. The perpetuation of the disease by infected stock is, however, unquestionable, and when once a stock of tulips has revealed the presence of tobacco necrosis viruses in some of the bulbs it would appear advisable to treat the whole stock as suspect, and if not to destroy it, certainly not to use it for forcing.

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SURVEY OF CEREAL ROOT EELWORM IN ENGLAND AND WALES, 1954

Contribution from the Conference of Advisory Entomologists, National Agricultural Advisory Service, compiled by J. F. Southey of the Plant Pathology Laboratory, Harpenden, Herts

During the spring and summer of 1954, all N.A.A.S. provinces and sub-provinces took part in a national random survey for Cereal Root eelworm, *Heterodera major* (O. Schmidt) Franklin. Entomologists were asked to examine one field growing oats on each of the farms already randomly selected for a survey of rabbit damage to winter cereals. In addition, the results of an examination of some fields of oats on farms visited for advisory purposes, and a few fields growing wheat and barley, were included. The survey was primarily concerned with the presence or absence of Cereal Root eelworm, but some simple observations were made on other factors, such as level of infestation, condition of crop and soil type. Observers were given the choice of two methods of examination, which had been selected as a result of an investigation of sampling methods in 1953.

Twenty samples of plants, each sample consisting of a four-inch length of drill, were lifted from each field. The roots were first examined dry, either in the field or in the laboratory. The number of samples on which one or more cysts were found was recorded. If no cysts were seen on dry examination the samples were carefully washed and examined one by one until cysts were found, recording the number of samples which had to be washed in order to find an infested sample. This was done from June onwards, when cysts were expected to be visible on the roots.

Soil sampling was done during the first six months of the year to detect cysts already present in the soil before cropping. Post-cropping sampling was not attempted because of the anomalous and inconsistent results which had been obtained by various workers when attempting to recover freshly-formed *H. major* cysts from soil. Fifty borings were taken from each field and the air-dried soil examined in the laboratory by the usual flotation method, using flasks or the Fenwick apparatus. Larval measurement was used as the criterion for the identification of viable *H. major* cysts ; in some cases this was supplemented by use of morphological characters. In the consideration of the results, " viable cysts " were taken as those containing larvae in the *H. major* length range (540–580μ).

Systematic sampling was used with both methods ; the samples were distributed more or less evenly over a field, roughly in the form of a grid. In some cases samples were taken by the district advisory officer and sent to the entomologist for examination. Observers were asked to record on standard forms the date of sowing, date of sampling, presence or absence of Stem eelworm and other pests or diseases, and to note the soil type and degree of damage, if any, to the crop. Crop damage was recorded by marking one of four categories—none, slight check, patchy, total failure. The soil classification used was : clay, clay-loam, silt-loam, loam, sandy-loam, sand, chalk, peat.

REGIONAL DISTRIBUTION

As a result of the survey and of previous observations, Cereal Root eelworm is now known to occur in all counties in England and Wales, except Cumberland, Westmorland, Anglesey, Radnorshire and Middlesex. (All of the administrative county divisions have been ranked as " counties " for this purpose). This

confirms the previous impression that Cereal Root eelworm is extremely widespread in Britain. In all, 367 fields were examined, of which 262 were on the randomly selected farms. Unless otherwise stated, only the random sample has been considered in examining the data. Cereal Root eelworm was found in 113 out of 262 fields—that is, in 43 per cent. Table 1 gives the figures for individual N.A.A.S. provinces. Where the soil sampling method was used the few fields of wheat and barley examined have been included.

TABLE 1

NUMBER OF FIELDS INFESTED

Province	Fields Examined	Fields Infested
Northern	11	7
Yorks and Lancs	20	15
East Midland	18	4
West Midland	26	11
North Wales	16	5
Mid Wales	36	8
South Wales	8	4
Eastern (Cambridge)	50	34
Eastern (Kirton)	5	2
South-Eastern (Reading)	17	8
South-Eastern (Wye)	18	8
South-Western (Bristol)	30	5
South-Western (Starcross)	7	2
	262	113

Although the figures are not in most cases large enough to show significant differences between individual provinces, it is interesting to note that the highest proportions of infested fields were found in the Yorks and Lancs, Eastern, and Northern provinces, whereas the proportions were lower in the West Midland and South-Eastern (Reading) provinces, where some of the most serious damage has been experienced. The proportions of infested fields were about the same for the Reading and Wye sections of the South-Eastern province, although, in fact, very little crop damage due to *H. major* has been experienced in the Wye sub-province. However, only very light infestations were found in the Wye area, where soil sampling was the only method used. The incidence of crop damage by Cereal Root eelworm is probably dependent much more on local conditions, particularly cropping practice and soil type, than on mere presence of the pest.

EFFECT OF SOIL TYPE ON INFESTATION

Results of the survey have corroborated reports that Cereal Root eelworm is more common and more severe on light, sandy soils than on heavy soils. Only fields of oats or mixed corn containing oats were considered in examining the data for this purpose. Table 2 gives the results obtained.

TABLE 2

CEREAL ROOT EELWORM AND SOIL TYPE

Soil Type*	Total Fields	Fields Infested	Plant Sampling: No. of Fields found Infested	Plant Sampling: Mean Infested Plant Samples (out of 20)	Soil Sampling: No. of Fields found Infested	Soil Sampling: Mean log(n+1) Viable Cysts per 500 grammes
		per cent				
Heavy	107	35	27	5·3	16	0·73
Medium	66	35	13	6·5	8	0·71
Light	63	60	28	9·0	14	0·93

* Heavy = clay and clay-loam : Medium = loam and silt-loam : Light = sandy-loam and sand.

A higher proportion of infested fields and heavier infestations occurred on the light soils than on the medium and heavy land. It is possible that the results obtained by plant sampling would be influenced by the fact that cysts are more difficult to find on plants taken from heavy clay soils, but this effect would probably not explain the difference observed between the medium and light soils, so it seems likely that the difference is a real one and not just due to relative ease of examination with different soils.

CROP DAMAGE IN RELATION TO INFESTATION AND SOIL TYPE

Considerable difficulty was experienced in recording crop damage due to Cereal Root eelworm, because of the various other factors—for example, other pests and diseases, soil conditions and fertility—which influenced the condition of the crop. In many cases it was impossible to estimate with certainty the effect due to Cereal Root eelworm in the presence of other factors, so the results obtained must be regarded as subject to a large error. For this reason, and because of the small number of fields involved, it was not possible with any confidence to relate the degree of damage to level of infestation. However, the figures in Table 3 show that the proportion of fields in which Cereal Root eelworm was detected was much greater for the fields of oats classed as damaged by eelworm than for those showing no damage. Damaged fields also showed, on average, a higher level of infestation as measured by both plant sampling and soil sampling methods. Fields classed as damaged comprise those in the " slight check " and " patchy " categories. Only one crop was recorded as being a total failure due to Cereal Root eelworm. On this field all twenty plant samples were infested and soil sampling showed 64 viable cysts in 500 grammes.

TABLE 3

CROP DAMAGE IN RELATION TO INFESTATION

	Plant Sampling			Soil Sampling		
	Total Fields	Fields Infested *per cent*	Mean Infested Plant Samples out of 20 for Infested Fields	Total Fields	Fields Infested *per cent*	Mean log (n+1) Viable Cyst Count for Infested Fields
No damage ..	116	26	5·3	60	27	0·70 (4 per 500 grammes)
Damage ..	46	89	8·9	22	82	1·04 (10 per 500 grammes)

In addition, the data suggest that crop damage was more evident on light soils than on heavier ones. Using the same soil classification as in Table 2, the proportions of fields on which damage was recorded were : Heavy—15 of 75 (20 per cent) ; Medium—7 of 52 (13 per cent) ; and Light—18 of 53 (34 per cent).

SPRING SOWING VERSUS WINTER SOWING

There was no evidence from the survey results that time of sowing, whether winter or spring, has any influence on Cereal Root eelworm attacks on oats. Considering only fields of oats or mixed corn examined by the plant sampling method, 66 out of 138 spring-sown crops were infested (48 per cent), as opposed to 23 out of 46 winter-sown crops (50 per cent). There was no evidence of any difference in average levels of infestation for the two times of sowing.

EFFICIENCY OF SAMPLING METHODS

Several provinces examined all or some of their fields by both plant sampling and soil sampling. The results in these cases have provided useful data for comparing the efficiency of the methods. For this purpose, fields visited for advisory purposes and results from parish surveys in the East Midland province have been included as well as the random fields :

		SOIL SAMPLING	
		Detected	Failed to Detect
PLANT SAMPLING	Detected..	43	17
	Failed to Detect	3	31

Soil sampling failed to detect cysts in 17 fields where they were found by plant sampling, and plant sampling failed in only 3 fields known, as the result of soil sampling, to be infested. Assuming that Cereal Root eelworm was in fact present in all of the 31 fields in which both methods failed to detect it, then soil sampling failed in 48 (17+31) cases and plant sampling failed in 34 (3+31) cases out of the 94 fields examined by both methods. Thus plant sampling was rather more efficient than soil sampling for detecting infestations.

To examine the relation between the results obtained by the two methods of sampling, the data from fields of oats or mixed corn sampled by both methods were used to calculate a regression coefficient for the proportion of plant samples infested on the population of viable cysts in the soil. Plant sampling results were expressed as angles of the percentage of plant samples infested and

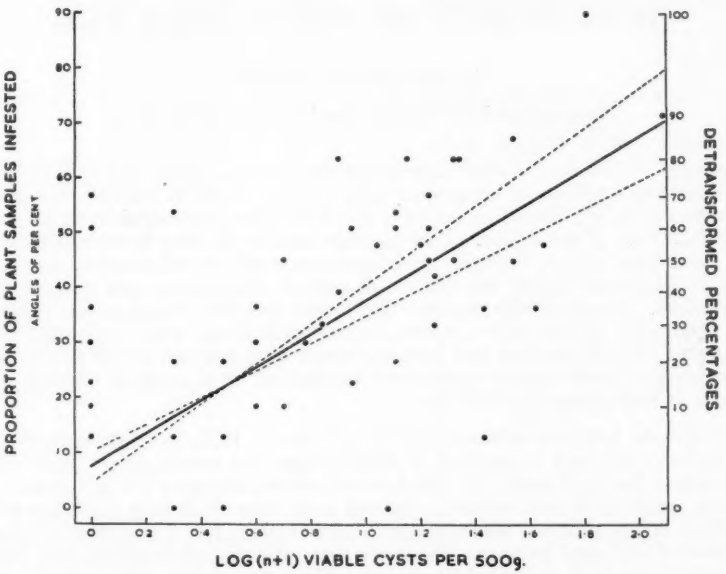

Fig. 1 Regression of plant infestation on population of viable cysts in the soil.
$b = +30{\cdot}40 \pm 2{\cdot}79$

plotted against soil sampling results expressed as log (n+1) viable cysts per 500 grammes. Fig. 1 shows the resulting scatter of points with the regression line and its 5 per cent fiducial limits. This shows the average relationship between the two methods. However, as may be seen from the individual plotted points, for any one field the relationship between the two estimates may be very different. The fact that plant sampling appears to have been more efficient than soil sampling for detecting Cereal Root eelworm is again reflected by Fig. 1, which indicates that on average up to about 3 per cent of plant samples may be infested where no viable cysts are found in the soil.

Out of 187 fields of oats or mixed corn examined by the plant sampling method, Cereal Root eelworm was found by dry examination of the roots in 82. Of the 105 fields which therefore gave negative results by this method, Cereal Root eelworm was only found in a further 7 after washing the roots in the laboratory. It is concluded that the extra work involved in washing the samples was not justified by the small amount of extra information obtained. Dry examination of the roots of samples of plants in the field is considered to be a sufficiently accurate sampling method for quick survey work.

I am much indebted to Mr. B. M. Church and Mr. A. H. Strickland for assistance with the statistical analysis and for advice on the presentation of the results.

HOST PLANTS OF WHEAT BULB FLY

by BARBARA M. STOKES

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The eggs of Wheat Bulb fly (*Leptohylemyia coarctata* Fall.) are laid in open soil, such as a fallow, or on ground with a partial cover of vegetation, such as a potato field, in preference to stands of wheat—the plant which is regarded as the chief host of the larvae. This suggests that the fly may breed additionally on other host plants, probably graminaceous weeds of open soils. Gemmill (1927) mentioned barley, rye and couch grass as host plants, and possibly also cocksfoot. Gough (1946) reported that larvae had been found in *Poa trivialis*, *P. annua* and *Agrostis alba* v. *repens*, as well as in couch grass, on arable land, and that *Phleum pratense* and *Lolium perenne* were infested in the laboratory. The present paper records experiments carried out on a range of possible host plants at Rothamsted in 1953–54.

Flies were bred out between June 18 and July 3, 1953, from pupae collected in the field and kept in captivity in muslin cages in a garden shed. Most were allowed to feed on bunches of wild flowers in water, though a few had additional honey, sugar or a meat extract. Mating took place from July 6 to August 5, and egg laying occurred between July 27 and October 12. The eggs were stored in pots of soil until January 1954, when they were placed on damp filter paper in petri dishes in an unheated glasshouse. The larvae were used for experiments as they hatched, and additional larvae were obtained in the same way from eggs washed out of soil samples.

Host Plants of Wheat Bulb Fly

Twenty-four plant species were selected for tests as host plants. These comprised four cereals, thirteen grasses, and seven close relatives of the wheat plant not normally found in England. In one series of experiments the plants were grown separately in 7-inch pots, to which eggs and/or newly hatched larvae were added between November and February. When the larvae began to pupate each pot was fitted with a circular waxed cardboard cover, into which fitted a lamp glass topped by a muslin-covered iron ring. Flies emerging from each host plant were caught and later identified. In a second series of experiments single shoots of each host plant were grown in soil in glass tubes with a drainage hole in the base. The tubes were plunged to one inch from the top in a dish of peat. One egg was placed under the soil near the glass in each tube, and in some a newly-hatched larva was also added. In these experiments it was possible to make observations through the glass. Emerging flies were caught in other tubes which were fixed over the open end by means of transparent adhesive paper.

The type of damage suffered by different plants was examined in the third series of experiments, in which newly-hatched larvae were placed on the roots of washed single shoots laid round the edge of an earthenware dish. The base and roots were covered with damp soil and the plants were examined some days later.

Larvae extracted from wheat plants were used in the fourth series of experiments to see if they would infest other hosts. They were placed on single-rooted shoots which were pulled up some days later and examined. Plants, larvae and soil were moved at the pupation time of the larvae to wooden emergence boxes fitted with a protruding removable glass tube in which the emerging flies moved towards the light. A few more experiments were made to see how far larvae moved in the soil. Wheat plants, with their roots covered in soil, were placed round the sides of dishes of different sizes, and larvae were placed at varying distances from the plants.

Table 1

Numbers of Eggs and Larvae Used and Flies Emerging in Host Plant Experiments

Host Plant	No. of Eggs	No. of Newly-hatched Larvae	No. of Flies Emerged
Grasses			
Agrostis alba v. *stolonifera*	2	3	1
A. tenuis	2	7	4
	2	4	1
Agropyrum repens	2	8	1
	2	0	1
Festuca pratensis	2	3	3
Poa pratensis	2	8	2
	2	1	2
P. trivialis	2	6	1
	2	3	1
Cereals			
Triticum vulgare	2	2	2
	2	3	4
Secale cereale	2	8	4
Plants not usually found in England			
Aegilops ovata	1	4	3
Triticum dicoccoides	1	0	1
T. dicoccum	1	0	1
T. turgidum	1	0	1

Larvae established themselves successfully and flies emerged from the following grasses: *Agrostis alba* v. *stolonifera* (fiorin), *A. tenuis* (common bent-grass), *Agropyrum repens* (couch grass), *Festuca pratensis* (meadow fescue), *Poa pratensis* (meadow grass) and *P. trivialis* (rough meadow grass). They also emerged from *Triticum vulgare* (wheat) and *Secale cereale* (rye), and from four plants closely related to wheat—*Aegilops ovata*, *Triticum dicoccoides* (wild emmer), *T. dicoccum* (emmer) and *T. turgidum* (rivet or cone). (Table 1).

Yellow shoots, which later turned brown and died (typical of Wheat Bulb fly attacks), were seen on *Dactylis glomerata* (cocksfoot), *Festuca rubra* (creeping fescue), *Hordeum murinum* (wall barley), *Lolium perenne* (ryegrass), *Poa annua* (annual poa), *Triticum durum* (macaroni wheat) and *T. compactum* (club wheat), but no flies emerged. No symptoms were seen on *Alopecurus pratensis* (meadow foxtail), *Hordeum vulgare* (barley), *Phleum pratense* (timothy) and *Triticum spelta* (spelt). Plants of *Avena sativa* (oats) died before tests could be made.

Flies emerged from single shoots of *Hordeum murinum* and *Secale cereale* grown in glass tubes, and larvae were observed to be well established in the plants shown in Table 2. The following plants showed signs of damage: *Agropyrum repens*, *Hordeum vulgare*, *Lolium perenne*, *Phleum pratense* and *Poa pratensis*.

TABLE 2

PLANTS IN WHICH LARVAE SURVIVED FOR A MONTH OR MORE

Host Plant	Date Experiment Began	Observations
Agrostis tenuis	March 4	May 5—Larvae still in shoot
Dactylis glomerata	November 27	May 5—Larvae in soil
Poa trivialis	March 4	May 4—Larvae wandering in soil
	March 4	April 22—Larvae seen feeding on outside of stems
Triticum vulgare	November 27	March 13—Larvae alive in dead shoot. New shoots given

For assessing the types of damage in different plants, newly-hatched larvae were placed on the plants on March 19, and all the plants were examined on March 30. Larvae were found in two wheat shoots, both of which were yellow, and in two shoots of *Agropyrum repens*, both of which were brown. There were two larvae in one of these shoots, but they were dead. Larvae were also found in two shoots of *Agrostis alba* v. *stolonifera*, one of which was green with a small brown entrance hole at the base, and in a green *Poa pratensis* shoot, also with a brown basal hole. The shoot was chewed within the outer sheaths. A yellow shoot of *Triticum spelta* contained a larva which had entered by a hole at the base, and the chewed area here showed as a three-tier clockwise spiral. In *Triticum durum*, which the larva had entered similarly, the centre of the plant was entirely eaten. In one shoot of *Dactylis glomerata* there were signs of chewing and in another a basal hole, though nothing was eaten in the centre. In *Agrostis tenuis* every tiller had a brown hole at the base and was chewed, but no larvae were found in any of them.

Larvae extracted from wheat plants on March 30 were placed on other plants, which were subsequently examined on April 14. Typical damage was recorded from *Agropyrum repens*, *Agrostis alba* v. *stolonifera*, *A. tenuis*, *Dactylis glomerata*, *Festuca pratensis*, *F. rubra*, *Lolium perenne*, *Phleum pratense*, *Poa annua*, *P. trivialis* and *Triticum vulgare*, but *Alopecurus pratensis* remained healthy throughout. To avoid decreasing the chances of the flies developing, the plants were not opened, but on May 12 pupae were found in the *Festuca pratensis* and

Triticum vulgare experiments while transferring the plants to wooden emergence cages. None of the pupae survived to the adult stage.

To test the movement of larvae in the soil, five wheat plants were set 1 inch apart round the edge of a pot and, on February 22, five newly-hatched larvae were placed in the centre, 3 inches from all the plants. By March 8, two plants had yellowish central shoots, one was doubtfully yellow and two were green and healthy. On April 2 the plants were examined and then replanted. One plant with a dead centre shoot contained a cast larval skin, and a feeding larva was seen in the plant next to it, although the centre shoot was still green. The third plant was healthy. The fourth plant was brown and rotten, and a larva was seen in the fifth plant, in which the shoot was still green. On April 28, two large larvae were found wandering in the soil, possibly fully fed, as pupation had already begun in other experiments kept in the same conditions.

Experiments were begun on April 1 using larvae extracted from wheat. Seventeen larvae were placed in each of four pot dishes containing six wheat plants, at distances of 8, 7, 6 and 5 inches respectively from the plants. In another dish of nineteen plants the same number of larvae were placed directly on the plant roots (shown in the table below as 0 inches). All the plants were examined on April 14. Although the experiment was continued till June, only one adult fly emerged, and that was from the trial at 6 inches.

Distance of larvae from plants (inches)	8	7	6	5	0
Condition of plants on April 14	2 healthy 4 dying*	3 healthy 3 dying†	1 healthy 5 brown	0 healthy 6 dying	12 healthy 7 yellow

* Opened and no larvae found. † Larvae found in one—pupation suspected.

CONCLUSIONS

Larvae can move at least 7 inches (a usual drill width) in the soil towards wheat and are probably capable of travelling greater distances. It has been established that Wheat Bulb fly can breed successfully on the following grasses : *Agrostis tenuis*, *Festuca pratensis*, *Hordeum murinum* and *Poa pratensis*, while *Agropyrum repens*, *Agrostis alba* v. *stolonifera* and *Poa trivialis* were confirmed as host plants. Flies were also bred from wheat and rye and from four plants related to wheat, *Aegilops ovata*, *Triticum dicoccoides*, *T. dicoccum* and *T. turgidum*. It is very probable that the fly can breed on *Dactylis glomerata*, *Triticum spelta* and *T. durum*, which were found to contain larvae in experiments, while typical damage was found in *Festuca rubra*, *Hordeum vulgare*, *Lolium perenne*, *Phleum pratense*, *Poa annua* and *Triticum compactum*, although no further evidence of them serving as food plants was obtained.

Thanks are due to Dr. H. C. Gough, who sent the pupae for the original stock of flies, to Dr. F. Raw, Mr. R. M. Dobson and Mr. J. W. Stephenson, who supplied extra eggs and larvae and to Miss Judy Horn, who made the emergence cages and helped in catching the flies. I am also grateful to Mr. H. Oldroyd of the British Museum (Nat. Hist.), who checked the identification of the flies bred from the various hosts.

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SOME STORAGE ROTS OF CELERY CAUSED BY *CENTROSPORA ACERINA* AND OTHER FUNGI

by P. H. LOWINGS

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During the season 1954–55 considerable rotting developed in celery stored at 33° F. for up to three months under semi-commercial conditions. The store contained celery from several sources in Cambridgeshire and Lincolnshire, and included batches of both early (self-blanching) and maincrop varieties. There appears to be little information available regarding the diseases affecting celery stored in the British Isles, and the organisms causing rotting were therefore investigated and their incidence assessed. The primary pathogens were found to be fungal in practically every case, soft-rot bacteria being associated almost entirely with advanced cases of the physiological " black heart " disease which had escaped culling during the packing of the store, or with primary fungal rots.

Centrospora acerina (Hartig) Newhall was the most interesting species encountered during the investigation ; it has been recorded only once before in this country, as a field disease of celery in Bedfordshire (Storey and Wilcox, 1953). It has, however, been reported to cause a severe celery storage rot in the United States (Newhall, 1944) and Canada (Truscott, 1944). The disease appeared in almost every batch of celery during the seventh or eighth week of storage, 21 per cent of the plants in one batch of early celery becoming severely infected by the end of the twelfth week. Of the remaining plants in this batch, 44 per cent developed symptoms of infection within a week of removal from storage. Symptoms developed more slowly in the maincrop variety, possibly due to a later onset of senescence, which Truscott suggests is an important factor in the development of this disease. The symptoms were similar to those described by Newhall, infection being largely confined to the crown and the base of the petioles, with the former eventually falling away completely (Plate III, 1). Conidia were produced very sparsely on the surface of the lesions, but there was no evidence that infection had spread from plant to plant during storage. It appeared that contaminated soil had been the source of inoculum, the primary lesions tending to occur in a ring round the crown where soil had lodged between the bases of the outermost petioles. Successful laboratory inoculations with pure cultures were made on mature plants at that location. In a few cases, however, typical *Centrospora* rots were found centred about wounds or bruises on the upper parts of the outer petioles (Plate III, 2).

On removing plants from storage, the cotton-wool-like mycelium of *Sclerotinia* spp., chiefly *Sclerotinia sclerotiorum* (Lib.) De Bary, was frequently found growing over the roots and crown, although these were rarely severely rotted. However, as the plants were packed with alternate layers " head to tail ", the fungus had often spread from the infected crowns to the foliage and petioles of the adjacent layers, causing a very destructive wet rot (Plate III, 3) similar to that described by Ramsey and Wiant (1941). These writers consider this to be the most severe disease of stored celery in the United States. Infected leaves and petioles appeared water-soaked at first, sometimes with a faint pink discoloration. Rapid collapse of the infected tissue followed, with the liberation of much fluid. Abundant aerial mycelium and occasional sclerotia were also present. Approximately 80 per cent of the plants in one batch of early celery were severely attacked after twelve weeks in store. The maincrop losses were

much less severe, although the incidence of contamination, gauged by the presence of mycelium on the crown and roots, did not appear to be less than in the early variety.

Many plants in each batch developed a wet rot of the leaves and petioles caused by *Botrytis cinerea* Fr. Sporulation was vigorous over the whole surface of the lesions but the rot was usually localized, becoming severe on the outermost, more senescent, petioles.

Although blight due to *Septoria apii-graveolentis* Dorogin is not normally considered to be a serious storage disease, a few plants were found which appeared to have become blighted in store (Plate III, 4). Mature plants sprayed with a dense aqueous suspension of fresh *Septoria* pycnidiospores did not become infected after more than ten weeks storage at 33° F. under humid conditions. However, natural infections of the leaves and petioles, maintained under similar conditions, were found to spread slowly. The leaves became water-soaked but developed no fresh pycnidia, although a few developed on the petioles. It appears, therefore, that the development of this blight during storage was probably due to the enlargement of incipient infections which had escaped notice during packing.

It is significant that the two most destructive rots among the celery examined were caused by soil-borne fungi ; this suggests that crops grown only in land known to be disease-free should be selected for storage on a large scale. Furthermore, *Sclerotinia sclerotiorum* is known to have a wide host range, and *Centrospora acerina* has been reported as capable of parasitizing practically every crop commonly grown in rotation with celery (Tompkins and Hansen, 1950). Control by crop rotation does not, therefore, appear promising, and the suitability of fungicidal treatment is being investigated.

This work was carried out during the tenure of a Treasury Senior Research Fellowship as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research. Mr. J. R. H. Nash-Wortham assisted in identifying *Centrospora*, and Mr. G. W. Goodwin took the photographs.

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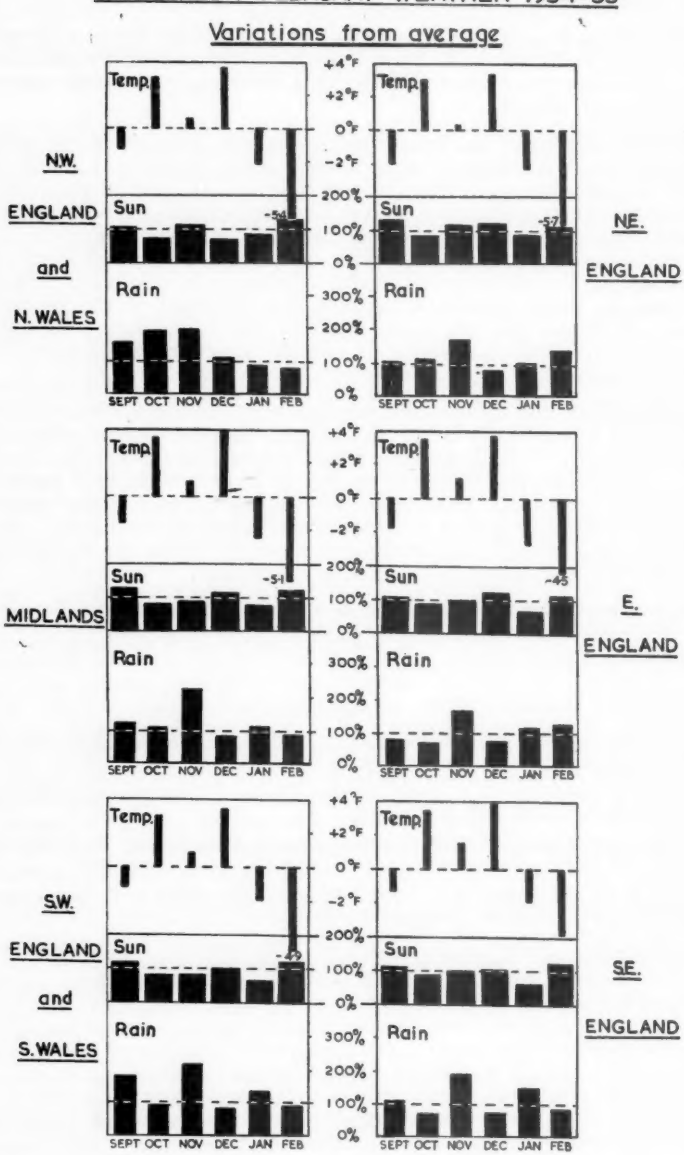
SEPTEMBER-FEBRUARY WEATHER 1954-55
Variations from average
NW. ENGLAND and N. WALES
NE. ENGLAND
MIDLANDS
E. ENGLAND
SW. ENGLAND and S. WALES
SE. ENGLAND
Temp.
Sun
Rain
+4°F
+2°F
0°F
-2°F
200%
100%
0%
300%
SEPT OCT NOV DEC JAN FEB

THE WEATHER OF ENGLAND AND WALES*

AUTUMN AND WINTER, 1954–55

The generally wet weather experienced in the summer of 1954 continued into the autumn, except in east and parts of south-east England. Sunshine was low on the whole in the three winter months, but the wide fluctuations in temperature in the six months under review, which affected uniformly most of England and Wales, are perhaps the most striking features shown in the diagrams. February was exceptionally cold and, as in 1953, was colder than the preceding month.

Although in September there were many sunny days, the month was rather cool with frequent thunderstorms, whilst winds, sometimes of gale force, blew persistently from the west. During the last week snow fell in Scotland, and colder weather with frost spread southwards. There was a change to milder weather in October, and although there was rather less than the average rainfall in the south, heavy rain followed by flooding occurred in the north. The first half of November was changeable. Stormy conditions on the 11th led to widespread flooding and, in the north, were accompanied by gusts of wind up to 100 m.p.h. In the third week, weather became rather more settled with some frost and fog, but later became very stormy over the whole area, and excessive rainfall occurred, accompanied by further flooding and gusts of wind exceeding 100 m.p.h. December, after starting with a relatively mild spell for the first six days, was stormy at times, and heavy thunderstorms in the south on the 8th were accompanied by small tornadoes. Colder weather from about 6th to 12th brought the first snow of the winter to the south. The rest of the month was generally rather mild.

The first three weeks of January gave two wintry spells, each lasting about a week, separated by a brief mild period. Snow or sleet was widespread at times, and snow lay to a depth of 8–10 inches in many districts. On the 21st an influx of mild air from the south-west brought rain, a rapid thaw, and fog. February was mild for the first week, but thereafter cold air spread from the north over the whole country. It was sunny at first, with wintry showers in the north, but temperatures continued to fall and, even during the daytime in many areas, rose only a little above freezing point. There was considerable snowfall and the strong northerly winds caused much drifting.

The weather for each of the six months September to February, inclusive, is represented graphically on page 108. Figures for the six districts of England and Wales are shown in terms of the deviation from the average of air temperature, sunshine and rainfall.

* These notes, and the diagram on page 108, are provided by the Agricultural Branch of the Meteorological Office, and published by permission of the Director.

NEW OR UNCOMMON PLANT DISEASES AND PESTS

***Cystopus candidus* on Aubrietia.** In June 1954, Dr. J. Macdonald found aubrietia plants in the St. Andrews Botanic Garden attacked by *Cystopus candidus* (Pers. ex Chev.) Lév., and reported it to the Plant Pathology Laboratory at East Craigs, Edinburgh. At approximately the same date, *Cystopus*-infected plants were also noticed in a garden at Blairgowrie, Perthshire, and shortly afterwards in East Lothian and the Royal Botanic Garden, Edinburgh, where infection had been noted by one of the Garden staff in 1953. In all cases the plants had been in their present position for many years. The symptoms on aubrietia are similar to those on other hosts and the effects seem to be relatively mild, except in very dry conditions. In heavy infections sepals and petals are attacked and the flowers fail to open or the colour of expanded petals is " broken ". There seems to be no recent common source for these occurrences on aubrietia. Inoculation with conidia from aubrietia to aubrietia, *Alyssum saxatile* and cauliflower resulted in infection of aubrietia only. The fungus on aubrietia may thus be a special form ; it does not differ in conidial characters from typical *Cystopus candidus* on *Capsella bursa pastoris.*

D. M. HENDERSON

***Macrosiphum gei* on Caryophyllaceae.** Hille Ris Lambers (*Temminckia*, 1939, **4**, 83, 95) recognized three component species in Theobald's conception of *Macrosiphum gei* (Koch) (*Aphididae of Great Britain*, 1926, **1**, 108). He regarded the true *M. gei* as confined to *Geum* spp. (Rosaceae) and various Umbelliferae. Börner (*Europae Centralis Aphides*, 1952, **1**, 160) agreed with this opinion. Both authors regarded *M. gei* as being polyphagous rather than heteroecious. In May 1952, Mr. K. G. V. Smith sent me a species of *Macrosiphum* which he described as heavily infesting sweet williams at Tettenhall, Staffs. This proved to be *M. gei*. At the time it seemed that this might be an isolated instance of anomalous infestation, such as occurs from time to time in Aphididae. However, in 1953 and 1954, I found similar infestations on various species of *Dianthus* at Cambridge. The fact that the siphunculi and femoral apices of these aphids were noticeably blackish made it improbable that they were *M. euphorbiae* (Thomas). On mounting a sample they were found to be *M. gei*, or at least morphologically indistinguishable from it ; but a single cross-transference test with *M. gei* from *Geum* to *Dianthus* was negative.

H. L. G. STROYAN

***Elachiptera cornuta* Damaging Gladioli.** Some gladioli, which had produced no flowers and not very vigorous foliage, were received in August 1954 from a garden at Ballater, Aberdeenshire. The base and lower half of the stem showed evidence of internal damage by insect larvae, but none was found. In the upper portion of one leaf, examination of a larval mine which was continuous with the damage at the base of the stem, revealed two dipterous pupae, from one of which a fly emerged. It was identified by Mr. R. L. Coe of the British Museum as *Elachiptera cornuta* (Fallén). This species is a common miner in the stems of graminaceous plants but does not appear to have been previously recorded damaging gladioli.

M. W. SHAW

(3004) Wt. 45 K.9 9/55 Hw.